RETOM™ - 51

HARDWARE/SOFTWARE MEASURING SYSTEM

USER'S GUIDE

RU.BRGA.51000-02 90

Cheboksary 2011

Contents

Introduction ***5***

1 RETOM-51 Program Installation ***5***

1.1 SW Installation *5*

1.2 Driver Installation for PC – RETOM-51 Communication via USB port *8*

1.3 Network Connection Setting for Communication via Ethernet *18*

2 Connecting Several RETOM-51 Devices to One Computer ***27***

2.1 Start of Several Devices *27*

2.2 RETOM-51 Devices Synchronization *28*

2.3 RETOM-51 Hardware Synchronization *30*

3 RETOM-51 Program Package ***31***

3.1 Main Window *31*

3.2 RETOM-51 Setup, Adjustment and Correction Program *37*

3.2.1 Application 37

3.2.2 Program Start 37

3.2.3 How to Work with the Program 38

3.3 Current and Voltage Independent Source Manual Control *39*

3.3.1 Application 39

3.3.2 Program Start 39

3.3.3 How to Work with the Program 39

3.4 Automatic Current Relay Test *46*

3.4.1 Application 46

3.4.2 Program Start 46

3.4.3 How to Work with the Program 47

3.4.4 Test Protocol 48

3.5 Automatic Voltage Relay Test *50*

3.5.1 Application 50

3.5.2 Program Start 50

3.5.3 How to Work with the Program 50

3.5.4 Operation Algorithm 51

3.6 Automatic Power Direction Relay Test *53*

3.6.1 Application 53

3.6.2 Program Start 53

3.6.3 How to Work with the Program 53

3.6.4 Settings and Test Parameters Window 54

3.6.5 Test Algorithm 56

4.6.6 Test Protocol 57

3.7 Automatic Frequency Relay Test *58*

3.7.1 Application 58

3.7.2 Program Start 58

3.7.3 How to Work with the Program 59

3.8 Automatic Distance Protection and Impedance Relay Test *60*

3.8.1 Application 60

3.8.2 Program Start 60

3.8.3 How to Work with the Program 60

3.8.4 Test Algorithm 65

3.8.5 Settings and Test Parameters Window 67

3.8.6 Test Results 71

3.8.7 Test Protocol 72

3.9 Time Lag Meter *73*
3.9.1 Application 73
3.9.2 Program Start 73
3.9.3 How to Work with the Program 74
3.9.4 Test Protocol 75
3.9.5 Test Oscillogram 76
3.10 Simulation of Fault Process Recorded in COMTRADE-format *77*
3.10.1 Application 77
3.10.2 Program Start 77
3.10.3 How to Work with the Program 77
3.11 Sum of Harmonics (definition of arbitrary shaped signals) *78*
3.11.1 Application 78
3.11.2 Program Start 78
3.11.3 How to Work with the Program 79
3.12 Power System RL-model *84*
3.12.1 Application 84
3.12.2 Program Start 84
3.12.3 How to Work with the Program 85
3.12.4 Test Protocol 90
3.12.5 Recommendations on Setting some Network and Operation Modes 91
3.13 Manual Control of Current Sources for Differential Protection test *93*
3.13.1 Application 93
3.13.2 Program Start 93
3.13.3 How to Work with the Program 94
3.14 Archive Handling *96*

Introduction

The present document is a User's Manual and defines software features of RETOM-51 system. The document describes the procedure for software installation and setup of communication between PC and RETOM -51, it contains the detail description of the standard program package included into the system delivery set.

1 RETOM-51 Program Installation

Attention! Computers included into RETOM-51 delivery set purchased from “Dynamics” company’s stock are delivered with the software and drivers already installed – no reinstallation is needed.

During program installation RETOM-51 should be disconnected from PC or switched off. Otherwise, Windows will automatically find a new device and start equipment installation wizard. However, this should be done only after RETOM-51 software is installed.

RETOM-51 software (SW) installation procedure consists of two parts:

- SW installation;
- installation of drivers for PC-device communication (when running USB port);
- network connection setting (when running Ethernet port).

1.1 SW Installation

Insert CD disk into CD-driver. If CD autorun mode is enabled in Windows XP/2000/Vista/7, in some minutes RETOM-51 SW installation window will be displayed.

If the autorun function is disabled, open disk content in Windows Explorer and run file *Auto* indicated with CD disk icon or press *Start* in Windows task bar, select *Execute* and enter *“x:\auto”* into text field (x – CD driver indicating figure). When CD disk runs the window shown in Figure 1.1.1 opens.

Figure 1.1.1

To run program installation wizard select *Install*.

If autorun is disabled, run program *Setup* located in *CD:\install\disk1*.

Further on, you can press all default buttons, i.e. agree to all questions provided by SW installation wizard. On completion of the procedure an icon for RETOM-51 program run will appear in menu *Start* and on the desktop.

If USB-ports are available: after SW installation is successfully completed, drivers should be installed for PC-RETOM-51 communication via USB-port (see Section 1.2).

After the SW installation procedure has been started the wizard offers you to install RETOM -51 programs to your PC, if you agree press *Next* for SW installation (see Figure 1.1.2).

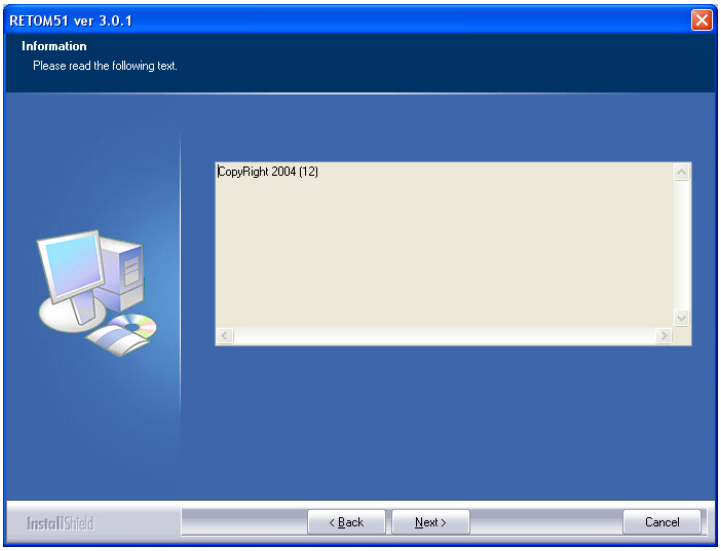


Figure 1.1.2

In the next window (see Figure 1.1.3) you are asked to select the location the program will be installed to. On default, SW will be installed into: *Program File\Dynamics\RETOM51*. You can change the location with the help of *Browse* button. However, we do not recommend you to do this at first installation. Press *Next* to continue.

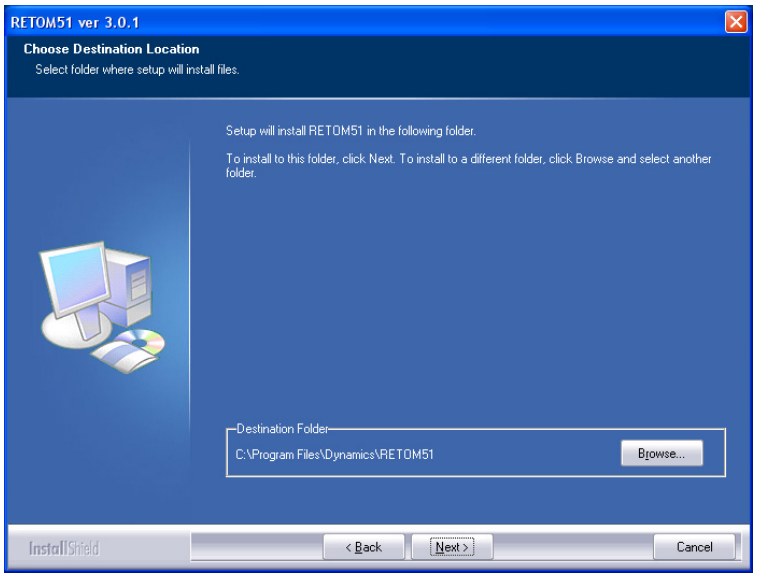

RETOM51 ver 3.0.1
Choose Destination Location
Select folder where setup will install files.
Setup will install RETOM51 in the following folder.
To install to this folder, click Next. To install to a different folder, click Browse and select another folder.
Destination Folder
C:\Program Files\Dynamics\RETOM51
Browse...
InstallShield
< Back
Next >
Cancel

Figure 1.1.3

In the next window (see Figure 1.1.4) the wizard suggests the program folder name, where from SW will be installed into menu *Start*. On default, it is *RETOM51*. You can change the folder name, but we do not recommend you to do this at first installation. Press *Next* to continue.

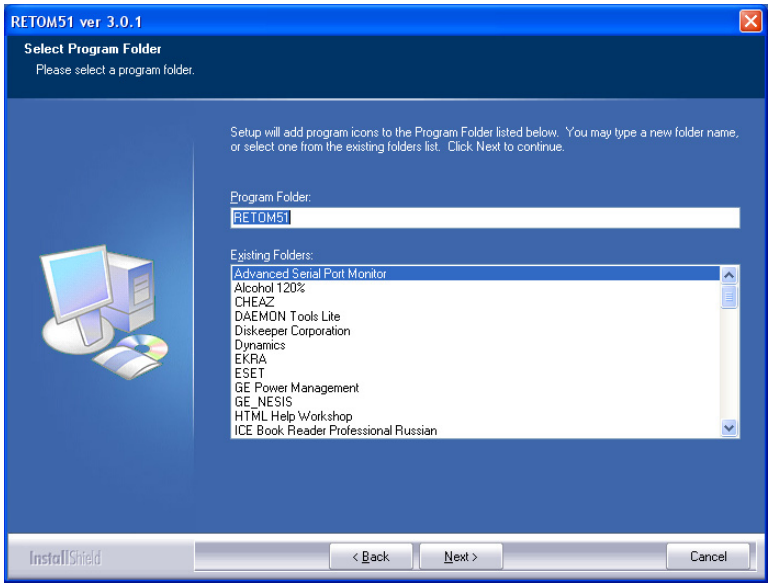


Figure 1.1.4

Installation procedure and its progress are shown in the window. (see Figure 1.1.5).

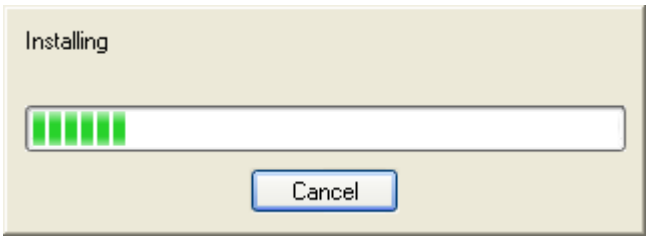


Figure 1.1.5

On completion of installation procedure the window with indication of its correct implementation appears. Press *Finish* to finish the process and to close program installation wizard. (see Figure 1.1.6).

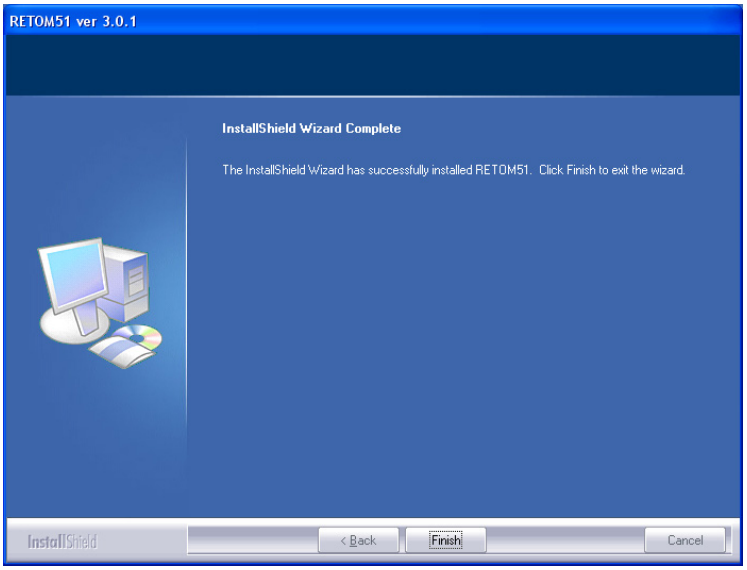


Figure 1.1.6

On completion of SW installation an icon for RETOM-51 program start appears on the desktop.

Besides, *Dynamics* directory appears in *Start-All programs* menu, where only one file – *RETOM-51* - will be located. If this directory exists already – e.g., RETOM-FH has been installed, this file will only be added to existing files and this will not affect earlier installed SW operation, e.g. RETOM-FH.

Before start to operate the device a driver for PC-RETOM-51 communication via USB-port should be installed or network connection for communication via Ethernet port should be set. Otherwise, PC cannot control the device.

The device communication with PC can be implemented either via Ethernet-port or USB-port.

If the device and PC communication is implemented via Ethernet-port no drivers should be installed, network communication should be set.

If you intend to use USB-port, then check whether all required drivers are installed and all USB-channels are operable.

Do not forget to update SW for RETOM-51 once in half a year or a year. All you need is to contact us. This service is free of charge. When updating SW you perform the same operations you did during the first installation. A new version will automatically replace the previous one. The driver should be updated as well.

1.2 Driver Installation for PC – RETOM-51 Communication via USB port

1.2.1 Driver Installation in Windows-XP/2000/Vista/7

Connect the device RETOM-51 with the PC via USB-port.

Switch on the device and wait until Installation wizard window appears. Sometimes it takes approximately one or two minutes. Follow the procedure shown below:

1) The wizard automatically suggests searching for the driver in Internet. This is not needed as all files required are delivered on a CD together with the main SW. Select *No, not this time* and press *Next* (see Figure 1.2.1).

Drivers can be installed either from installation CD or specific location *c:\Program Files\Dynamics\RETOM51*; the latter is preferable as all programs required were copied from the CD to this directory during SW installation.

Note – If you have connected and switched the device on before RETOM-51 program installation, Windows will find a new device. It is not necessary to give up installation; however the driver should be installed from CD.

1. No, not this time
Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
Windows will search for current and updated software by looking on your computer, on the hardware installation CD, or on the Windows Update Web site (with your permission).
Read our privacy policy
Can Windows connect to Windows Update to search for software?
Yes, this time only
Yes, now and every time I connect a device
No, not this time
Click Next to continue.
< Back
Next >
Cancel
2. Next

Figure 1.2.1

2) Next window suggests doing installation either automatically or from selected location. If there is a CD with RETOM-51 SW in the PC, automatic procedure can be used - select *Install the software automatically.* However, we recommend the second variant - press *Install from a list or specific location* (see Figure 1.2.2).

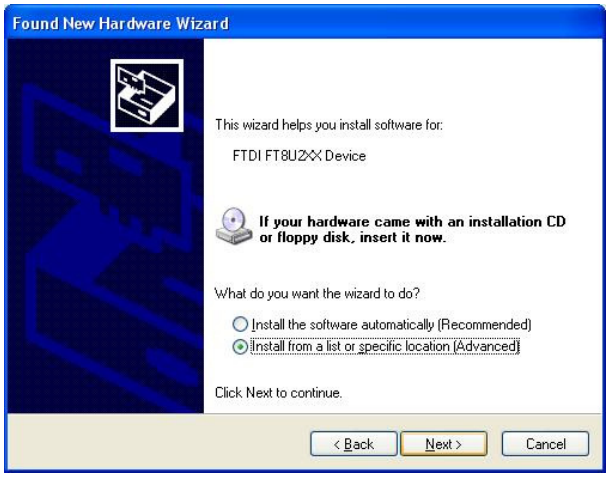

Found New Hardware Wizard
This wizard helps you install software for:
FTDI FT8UZXX Device
If your hardware came with an installation CD or floppy disk, insert it now.
What do you want the wizard to do?
Install the software automatically (Recommended)
Install from a list or specific location (Advanced)
Click Next to continue.
< Back
Next >
Cancel

Figure 1.2.2

3) If you select *Install from a list or specific location*, select *Search for the best driver in these locations* and *Include this location in the search* below in the next window. Press *Browse* (see Figure 1.2.3).

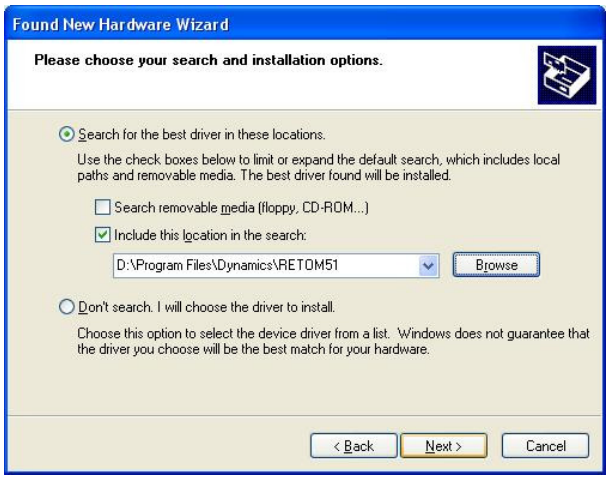

Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
D:\Program Files\Dynamics\RETOM51
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

Figure 1.2.3

4) After pressing the *Browse* button a window showing directories appears. Select the following: *C:\Program Files\Dynamics\RETOM51* and press *OK* to go back to the previous window (see Figure 1.2.4).

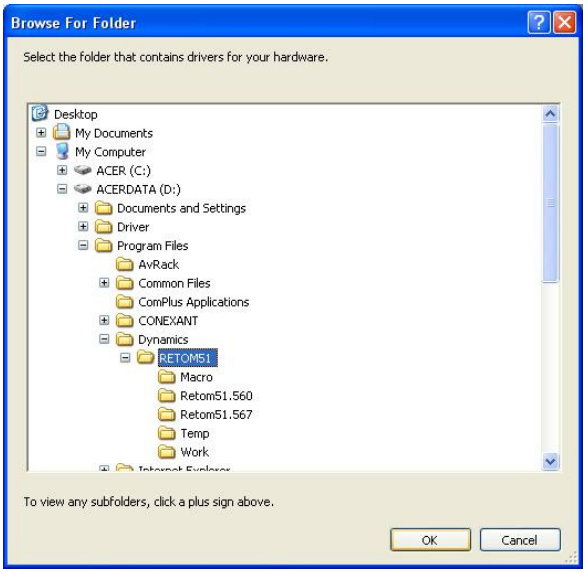


Figure 1.2.4

5) There is a path to driver in the window. Press *Next* to continue the installation (see Figure 1.2.5).

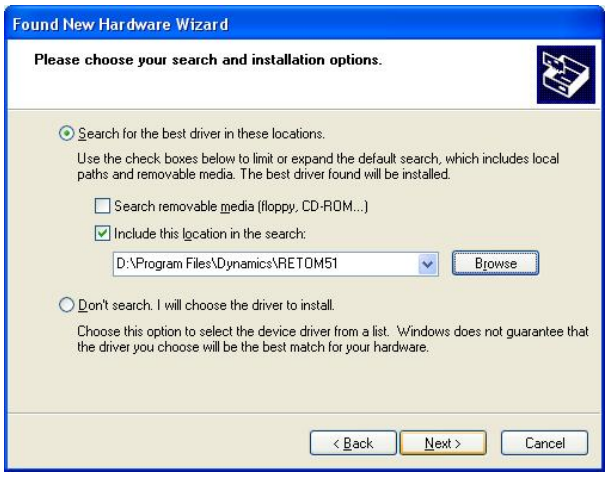

Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
D:\Program Files\Dynamics\RETOM51
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

Figure 1.2.5

6) Wait until the search ends and press *Next* (see Figure 1.2.6).

Figure 1.2.6

7) As our program has not been tested in Microsoft laboratory, security service window appears. To continue press *Continue Anyway* (see Figure 1.2.7).

Hardware Installation
The software you are installing for this hardware:
FTDI FT8U2XX Device
has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)
Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the hardware vendor for software that has passed Windows Logo testing.
Continue Anyway
STOP Installation

Рисунок 1.2.7

8) On completion of driver installation the termination window appears. Press *Finish* to terminate the wizard operation (see Figure 1.2.8).

Figure 1.2.8

On completion of driver installation check the system operability.

The procedure of system operability check is as follows:

- switch off the device and disconnect it from USB-port;
- call the window *Device Manager* (pay attention to section *Universal Serial Bus (USB) Controllers* – it should not include a string: *FTDI DT8U2XX Device*);
- connect the device to the same USB-port and switch it on (at least in 1 minute after it has been switched off);
- once again pay attention to section *Universal Serial Bus (USB) Controllers* – a string *FTDI DT8U2XX Device* appears there in 10-40 s after the device is switched on; this indicates that the system has recognized the device and is ready to work with it;
- start RETOM-51 program;
- set any signal (e.g. U_a = 100 V);
- check whether a signal exists with an external device.

If the system operates, the installation is completed.

1.2.2 Second Way to Install USB Driver in Windows-XP/2000/Vista/7

Installation of USB driver can be made several times (e.g. if automatic driver installation is unsuccessful) and nothing fatal happens.

To install the driver from “RETOM-51” program go to *Setup* menu item and select *Install USB driver* (Figure 1.2.9).

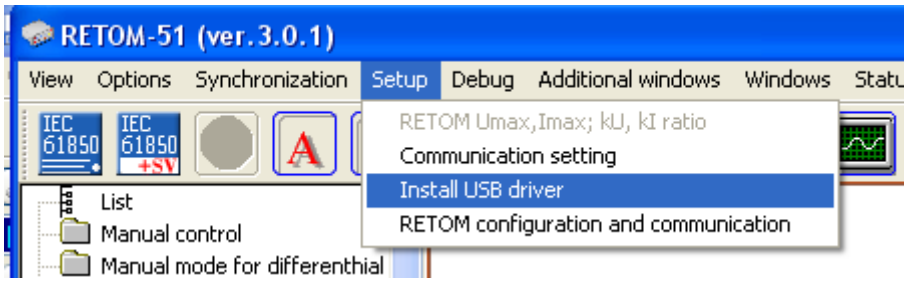


Figure 1.2.9

Start the driver installation wizard. The procedure of its handling is described above. (see 1.2.1).

Select this menu item to start the installation wizard, which rewrites USB driver from *RETOM* to *WINDOWS* directory and is registered in its device list. The same can be done by right clicking on file *\Program Files\Dynamics\RETOM51\ftd2xx.inf* and selecting *Install*.

1.2.3 Possible Problems when Installing USB Driver in Windows-XP/2000/Vista/7

Problems occurring when installing USB driver and ways of their correction are described bellow:

1) The driver installation wizard does not start. RETOM-51 program is installed. The device is switched on and connected to USB-port.

If this occurs during first installation, several reasons are possible.

The first and the most frequent reason is that in the majority of cases PCs are purchased together with RETOM-51 system from “Dynamics” company’s stock with SW and drivers already installed (but the program could be deleted during operation). To check whether the driver is available, do the following in series: *Start - Control Panel– System – Device Manager - Universal Serial Bus Controllers* and note whether the string FTDI DT8U2XX Device (Figure 1.2.10) exists when the device is switched on and disappears when the device is switched off. This means that RETOM-51 driver is already installed and no repeated installation is required. Check system operability.

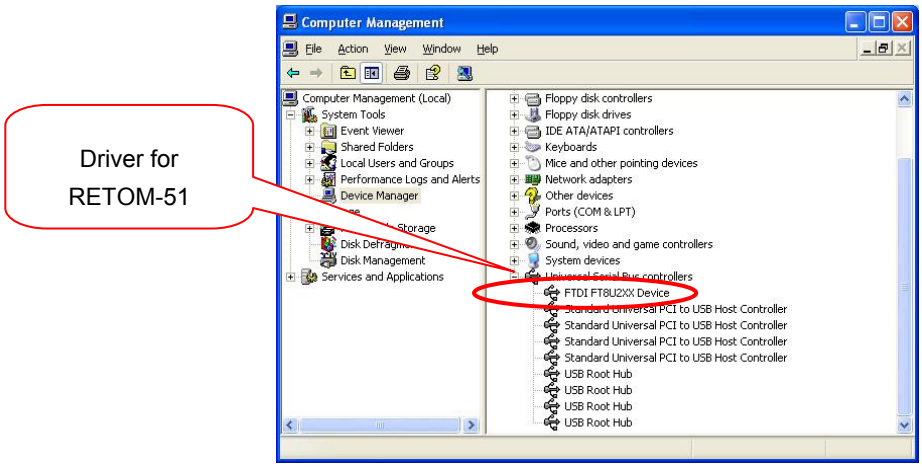


Figure 1.2.10

Second possible reason relates to OS Windows installed in PC. As there is no automatic diagnosis and the Equipment Installation wizard self start available in Windows, install the driver manually.

Third possible reason relates to other device earlier installed into the system, which applies FTD products (mobile phones, USB-COM converters, others including RETOM-VCH). In this case install the driver manually (item 7 - Operation together with RETOM-FH/25).

Problem solution. Try to install the driver again, nothing fatal would happen. Select the *Setup* menu item and *Driver Installation* subitem in RETOM-51 program (see 1.2.2 Second way to install USB driver).

2) The driver installation wizard does not start. RETOM-51 program is installed. The device is switched on and connected to USB-port.

Hardware failure. Very seldom – non-operating USB-port. It can be faulty either in PC or in the device. To find out what USB-port is faulty, connect the device to other PC USB-port or connect other USB-device (e.g., “mouse”) to this PC port.

USB-ports are simply disconnected. It is necessary to enter BIOS during PC startup, to enable USB function and to repeat the driver installation procedure. This is possible if the PC was used with RETOM-41M.

3) System does not run. Program and driver are installed. The driver installation wizard starts. Possibly, the device is connected to other USB-port.

This driver has one special feature – it is assigned to a certain controller, which serve one USB-port (the device is connected to when the driver is installed) or several USB-ports and continues to function with this controller only (the same as the device). If the PC has several ports, it is recommended to define what ports the device will use (except for the one, which the driver has been installed in) and what ports it will not use, i.e. to define ports and controllers. It could be useful for driver installation into other devices.

If the PC has several USB-ports and each of them is assigned to a certain controller, the device will not operate, if it is connected to other ports. The driver should be reinstalled into every port to make it possible. The installation procedure is the same as described above. We do not recommend to install the driver to more than

two ports (driver installation to two ports ensures simultaneous operation with two RETOM-51 devices) because problems might occur with other USB-devices.

The procedure of checking what USB-ports should operate with RETOM-51:

- exit RETOM-51 program;
- switch off the device;
- connect the device to other port;
- switch on the device: if driver installation wizard starts, then we either miss this port or install the driver to it;
- start RETOM-51 program;
- issue a signal (e.g., U_a = 100 V);
- check this signal with external device.

Remember the ports the device operates with and always connect it only to them in future.

4) After the program and the driver for RETOM-51 were installed, an earlier installed program RETOM-FH/25 (USB) and/or RETOM-51 fails to run.

If RETOM-FH/25 (USB) is already installed in PC and operates via USB-port (if it operates via COM-port, no need to pay attention to it as it does not affect RETOM-51 system functioning), then it might happen so that when installing the driver for RETOM-51 no installation wizard starts and the program cannot find the device. This means that the system has mistaken RETOM-51 for RETOM-FH/25and has started its driver. In such case connect the device to other USB-port. If this occurs in all ports (no RETOM-FH/25 - free port is found), the driver installation should be changed.

Procedure of RETOM-51 driver installation to the port occupied by RETOM-FH/25 driver:

Call the window Device Manager and view section Universal Serial Bus Controllers. When RETOM-51 is connected the driver for RETOM-FH/25 appears (see Figure 1.2.11).

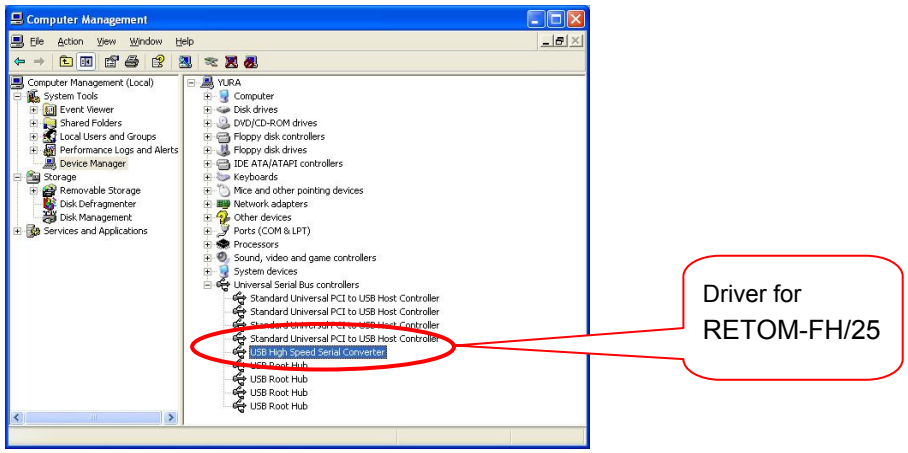


Figure 1.2.11

- Select and call *Properties*, a window appears, select the tab *Driver* and press *Update*.

This can be done directly in *Device Manager* window by right clicking the mouse – call a list of available functions and select *Update Driver Software* (Figure 1.2.12).

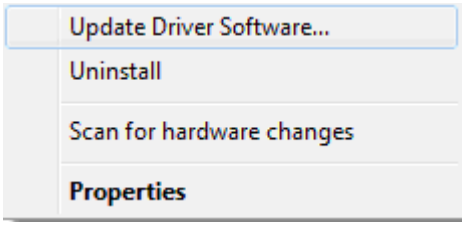


Figure 1.2.12

- The installation wizard starts and we partially change the above-described process. Change search and installation parameters. Set other variant – *Don't search. I will choose the driver to install*. Press *Next* (Figure 1.2.13).

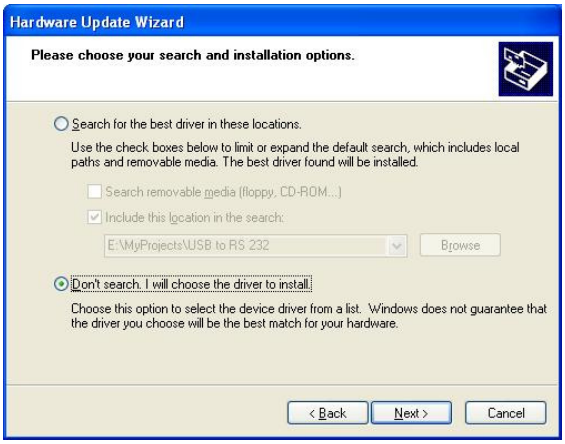

Hardware Update Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
E:\MyProjects\USB to RS 232
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

Figure 1.2.13

- In the next window (Figure 1.2.14) the program offers the required driver from the list but the required drive is not included there (it has not been installed in the system yet).

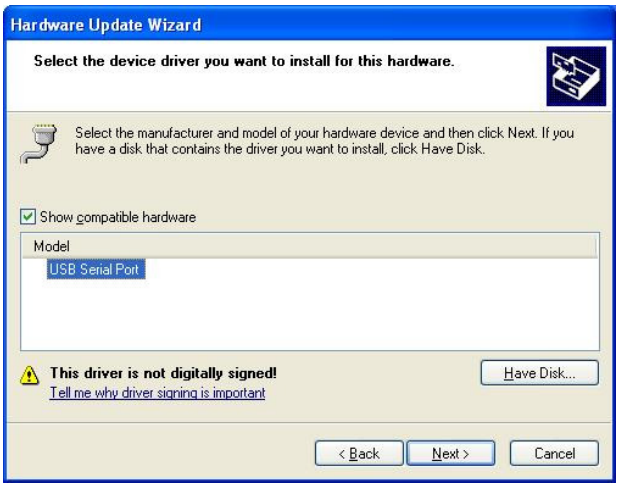
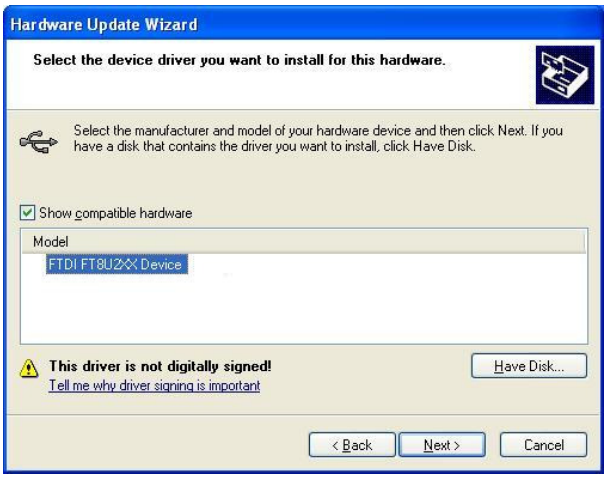

Hardware Update Wizard
Select the device driver you want to install for this hardware.
Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver you want to install, click Have Disk.
Show compatible hardware
Model
USB Serial Port
This driver is not digitally signed!
Tell me why driver signing is important
Have Disk...
< Back
Next >
Cancel

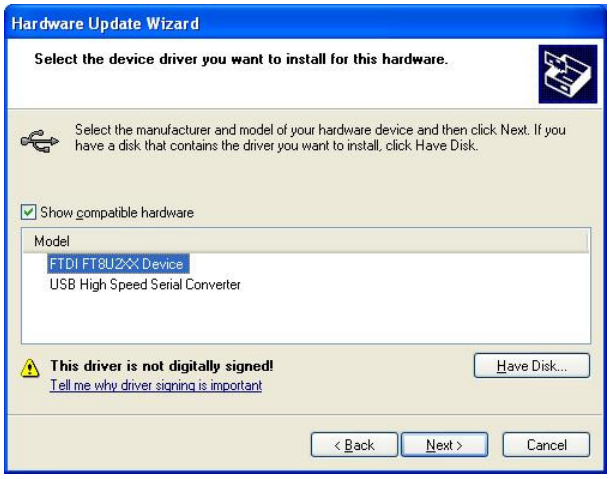
Figure 1.2.14

- The driver should be installed with direct indication of its location. For this press *Install from disk*. Select *Browse* in the window *Installation from disk* and set the driver location path FTDI FT8U2XX, e.g.: C:\Program Files\Dynamics\RETOM51 and go back to the previous window.

The driver we need (Figure 1.2.15a) or a list of two drivers (Figure 1.2.15b) are already shown in this window.


Hardware Update Wizard
Select the device driver you want to install for this hardware.
Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver you want to install, click Have Disk.
Show compatible hardware
Model
FTDI FT8U2XX Device
This driver is not digitally signed!
Tell me why driver signing is important
Have Disk...
< Back
Next >
Cancel

a)


Hardware Update Wizard
Select the device driver you want to install for this hardware.
Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver you want to install, click Have Disk.
Show compatible hardware
Model
FTDI FT8U2XX Device
USB High Speed Serial Converter
This driver is not digitally signed!
Tell me why driver signing is important
Have Disk...
< Back
Next >
Cancel

b)

Figure 1.2.15

If there is no *FTDI FT8U2XX* in the list, try to install the driver again. Select menu item *Setup*, subitem *Install Driver* in the RETOM-51 program" (see *Second way to install USB-driver*) and select *FTDI FT8U2XX*.

- Select *FTDI FT8U2XX* and *Next* following the above-described installation procedure.

Check RETOM-51 and RETOM-FH/25 operation. Please, note that you should not connect RETOM-FH/25 to the port, which RETOM-51 driver has been installed to (provided that the PC has at least two ports).

If the port is unique, RETOM-FH/25 will not operate. You should install its driver again in this case.

5) After the program and the driver for RETOM-51 were installed the earlier installed system RETOM-FH/25 does not operate.

If the program RETOM-FH/25 was earlier installed into PC and it operates via USB-port, it could happen that the driver for RETOM-51 will replace the earlier installed RETOM-FH/25 driver assigned to this port and, therefore, RETOM-FH/25 does not operate.

It is necessary to switch off and disconnect RETOM-51, connect RETOM-FH/25 to other port, switch it on and install its driver. However, the installation procedure should be changed. If the system recognize it as RETOM-51, go to *Start - Control Panel – System – Device Manager - Universal Serial Bus Controllers* and check whether there is a string *FTDI FT8U2XX Device*. If so, update the driver. Select manually the following: *Don't search. I will choose the driver to install*. Press *Next* (Figure 1.2.16).

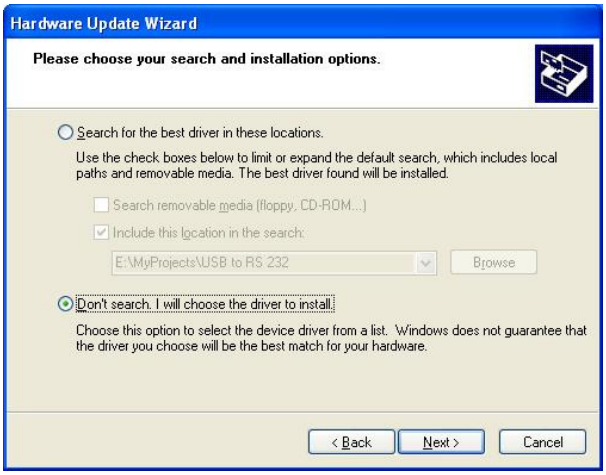

Hardware Update Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
E:\MyProjects\USB to RS 232
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

Figure 1.2.16

The program suggests selecting a driver from the list in the next window (Figure 1.2.17).

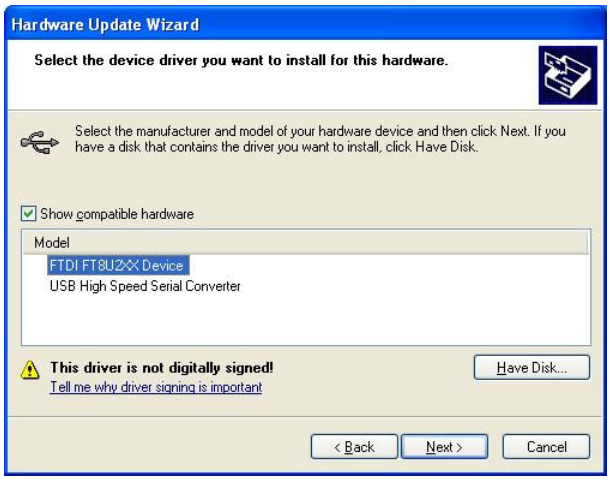

Hardware Update Wizard
Select the device driver you want to install for this hardware.
Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver you want to install, click Have Disk.
Show compatible hardware
Model
FTDI FT8U2XX Device
USB High Speed Serial Converter
This driver is not digitally signed!
Tell me why driver signing is important
Have Disk...
< Back
Next >
Cancel

Figure 1.2.17

Select *USB High Speed Serial Converter* and install it.

If there is no driver you need in the suggested list, install it from CD disk delivered together with RETOM-FH/25.

After driver is installed check program operation with RETOM-FH/25. Do not switch it off, connect RETOM-51 to other port and start its program. Check simultaneous operation of two devices.

6) After the program and the driver for RETOM-51 were installed, the earlier installed USB-COM converter program does not operate.

This problem might happen with some USB-COM adapters intended for microprocessor relay protection terminal communication. Its reasons are the same as described in item 4. Troubleshooting is described there as well. If you use RETOM-FH/25 and USB-COM converter as well, be careful to select the driver correctly, as there could be three types of drivers in use.

7) Operation together with RETOM-FH/25*.*

If you intend to use RETOM-51 and RETOM-FH/25 together in one PC, please, note that this is possible if only their drivers are installed to different USB-ports, and if you always connect them to assigned USB-ports. If this condition is ignored, the devices will not operate.

8) How to delete FTDI FT8U2XX driver?

If you need to delete FTDI FT8U2XX driver from the system, use the program *FTD2XXUN.EXE*, which is included into RETOM-51 program set and is located together with the driver.

Start the program. The window (see Figure 1.2.18) opens. Press *Continue*.

FTDI D2XX Uninstaller Version 2.2
If your USB device is connected, please unplug it now...
Press Continue to uninstall the drivers, or Cancel to quit.
Continue
Cancel

Figure 1.2.18

When you delete the driver, remember that it deletes all similar drivers. Therefore, if installed, RETOM-FH/25 and USB-COM drivers will be also deleted.

After confirmation a second window with the message about completion of the process appears (see Figure 1.2.19).

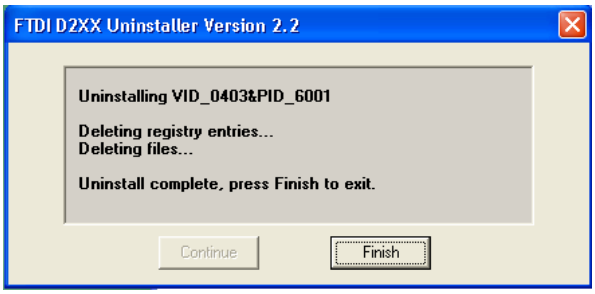


Figure 1.2.19

9) The driver installation did not help and the PC does not “see” the device anyway.

If the driver installation did not help and the PC does not “see” the device anyway, do the following:

- delete other drivers assigned to USB-ports. This is made in *Device Manager* window. To call it do the following: press *Start*, select item *Control Panel*, find the icon *System* in the window that opens. In the next window *System properties* find tab *Equipment*, click *Device Manager*. In the next window select *Universal Serial Bus (USB) Controllers*. Take care not to damage the system when you delete drivers. If you are not sure, contact specialists;
- delete RETOM-51 driver that you have just installed (item 8);

- switch off RETOM-51. Disconnect all external USB-devices, including RETOM-51, from PC;

- restart the PC and check that there are no USB drivers connected to PC. Go to *Device Manager* again and check item *Universal Serial Bus (USB) Controllers*;

- connect RETOM-51 to USB-port, switch it on and install its driver any way you like;

- check device operation (Ua = 100 V);

- reinstall all drivers that you have deleted and check operation of reinstalled device and RETOM-51. This will help you to find the device which is in conflict with RETOM-51. If you find it, it will be necessary to assign each USB-device to a separate port, to install its driver and to connect it always to this port only. When connecting to other USB ports this device may not operate. The same is about the case when RETOM-51 and RETOM-FH/25 operate together

10) USB communication troubleshooting

Communication with RETOM-51 can be established only after LED *Availability* becomes active on its front panel. When you switch on the connected device a string *FTDI FT8U2XX* must appear in the *Device manager* list, section USB. If not, do the following:

- connect the device to other port;

- reinstall the driver;

- check whether communication cable is OK (if faulty, take another cable). Cable USB2.0 should be used for USB;

- USB controller should be permitted in BIOS, i.e. seen in Device Manager. If not, enter BIOS and activate it;

- check with other PC;

- check with other device.

11) RETOM-51 program troubleshooting

Resolution of the monitor should be at least 800×600.

To run special programs (including panel test programs) under Windows 98 IE6 shall be installed (use the installation package on CD).

When a fault occurs in RETOM-51 (disturbances, exceed of current and voltage range), the program issues a message and terminates testing. Check connection circuits, load, current and voltage gain and constraint factors in program (button *UI*< in main program window toolbar).

Requirements to power supply are specified in RETOM-51 description.

RETOM-51 and tested equipment should be grounded.

Procedure of RETOM-51 switching on: connect the communication cable, switch on the PC, switch on the device, start the RETOM-51 program, wait until RETOM-51 is ready (LED *Availability* lights) and only then start a testing program.

Procedure of RETOM-51 switching off: close the main program window (device's power units are correctly switched off) and only then switch off the toggle *Mains* on RETOM-51.

Recommendation: Make copies of archives. Panel testing programs save intermediate results into temporary files during operation and in case of program start after a failure, read results from these files. Before you start the process of testing, check all settings and parameters of the test.

Any protocol conversion into *WORD* or *EXCEL* requires a lot of resources. Therefore, we recommend to save results in the archive first. After testing it is also recommended to save results in the archive without waiting for system notification.

1.2.4 Driver installation in Windows 98(ME)

The installation procedure is as follows:

- before installation check that USB controllers are allowed to operate in BIOS; if not, activate them and restart the PC;

- check that USB controller drivers are installed in Windows 98(ME) OS; if not, install them and restart the PC;

- install the program from the CD;

- connect RETOM-51 to USB-port and energize the device.

Installation procedure is carried out by using standard Windows 98(ME) methods, via Start – Control Panel – Install Equipment.

You might face similar problems as in XP and 2000.

1.3 Network Connection Setting for Communication via Ethernet

1.3.1 Network Connection Setting at the First Connection of a New RETOM

For running RETOM via Ethernet at the first connection of a new RETOM device do the following:

- Press on the communication icon on the toolbar of the program main window (Figure 1.3.1).

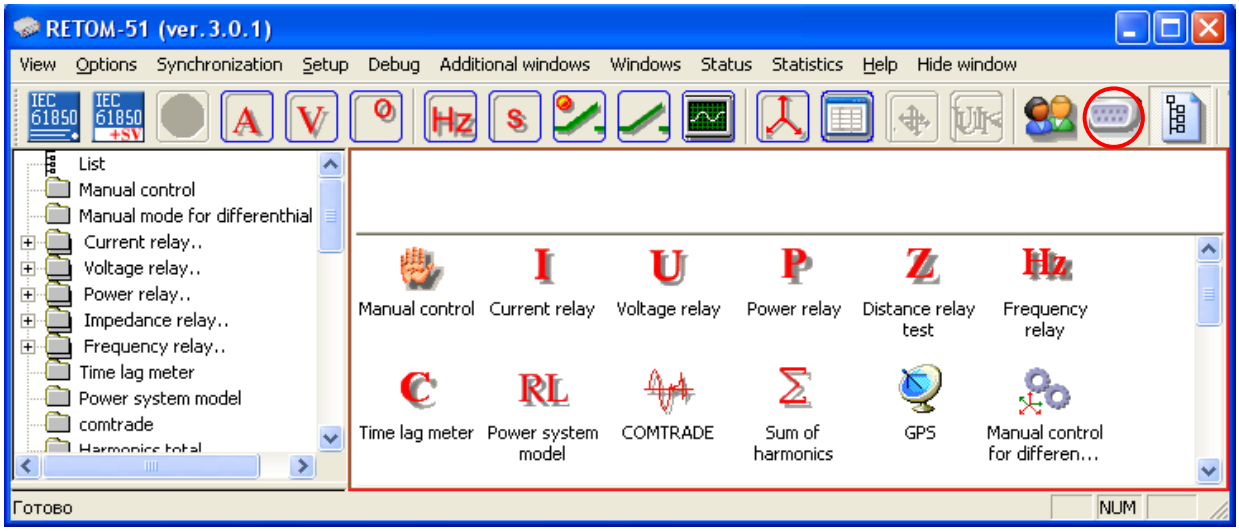


Figure 1.3.1 – Main window toolbar

- The window “Connection settings” will be opened (Figure 1.3.2). If you select Ethernet communication channel you will see IP-address of RETOM device in the input field (the address entered during the previous work session is saved there, but it is empty initially) and “Ok” button to be pressed.

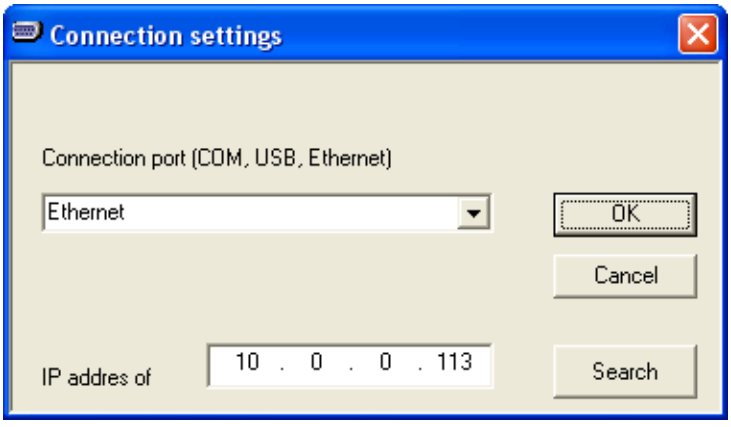


Figure 1.3.2 – Connection settings

- Search utility and settings of RETOM via Ethernet will start.

- If there are several network adapters in the PC select the one to which RETOM device is connected (Figure 1.3.3) in the window appeared before.

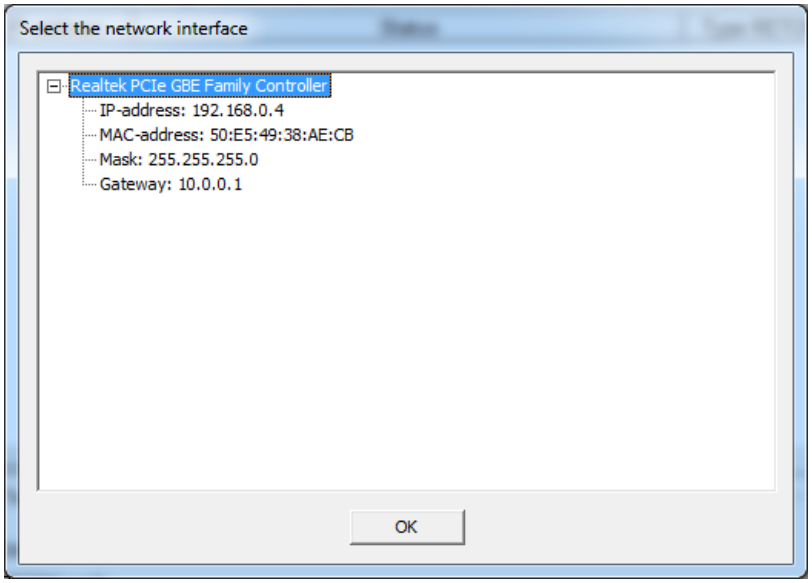


Figure 1.3.3 – Window “Select the network interface”

- In the next window (Figure 1.3.4) search will be started or can be started by pressing the button “Search” to fill the list of RETOM devices found.

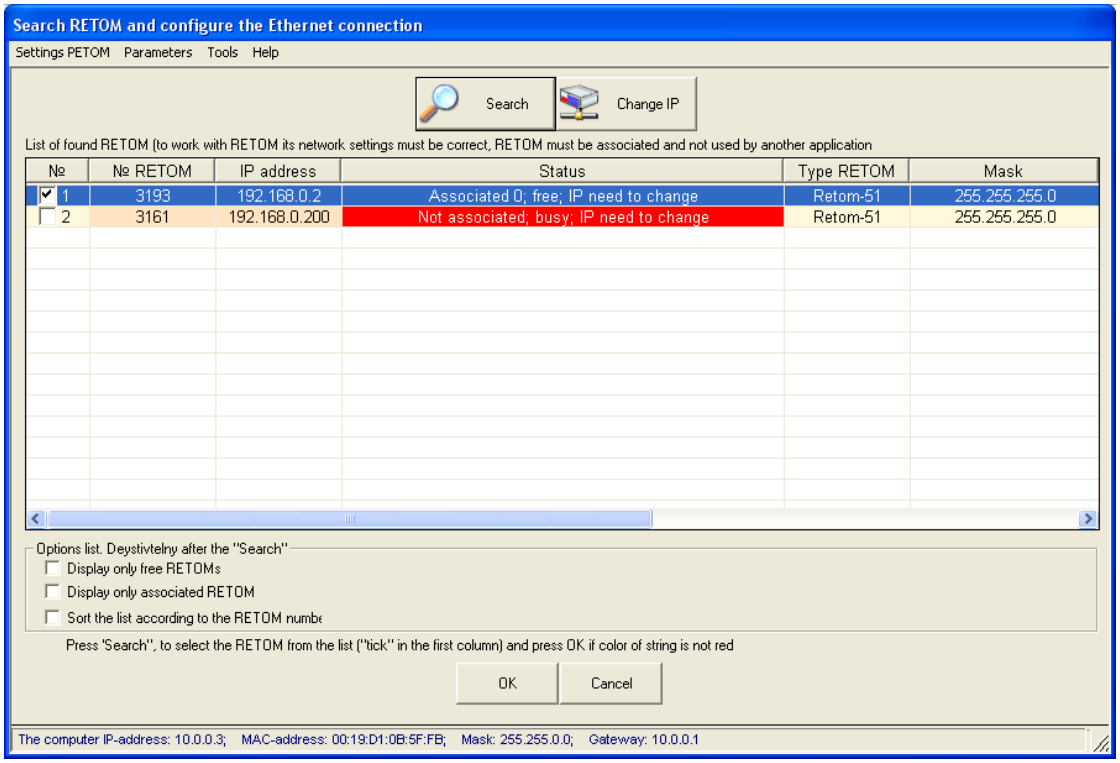


Figure 1.3.4 – Search utility and setting of RETOM via Ethernet

- Select the needed RETOM device (only one device can be active, check the first column of the selected device)

- If required RETOM should be adjusted (especially if the column “Status” is red (see Figure 1.3.5), that means: 1) RETOM is not associated; or 2) RETOM network settings are not correct; or 3) RETOM is occupied by other application). Please note that for the purposes of network security RETOM settings can be changed only if the RETOM is associated (bound to the given PC) or when the association is reset:

- *RETOM is not associated.* Reset (clear) the association – press the button “Association” on RETOM and hold it within 5 seconds (the association is zero filled, RETOM shows IP-address 192.168.0.2, mask 255.255.255.0, gateway 192.168.0.1). After that press once again the button “Search” to update the list.

- *Network settings of RETOM are not correct* (they should be set after having been associated or reset of the association) – set them manually or connect Ethernet cable directly to RETOM from the PC and select in the menu «RETOM settings" - "RETOM autosetting". Ethernet board reloads after the settings have been made so wait 5 seconds before continuing the operation.
- *PETOM is occupied by other application.* Close that other application running with the selected RETOM (when activating the communication with RETOM the device will be shown as in use, "in use – own").

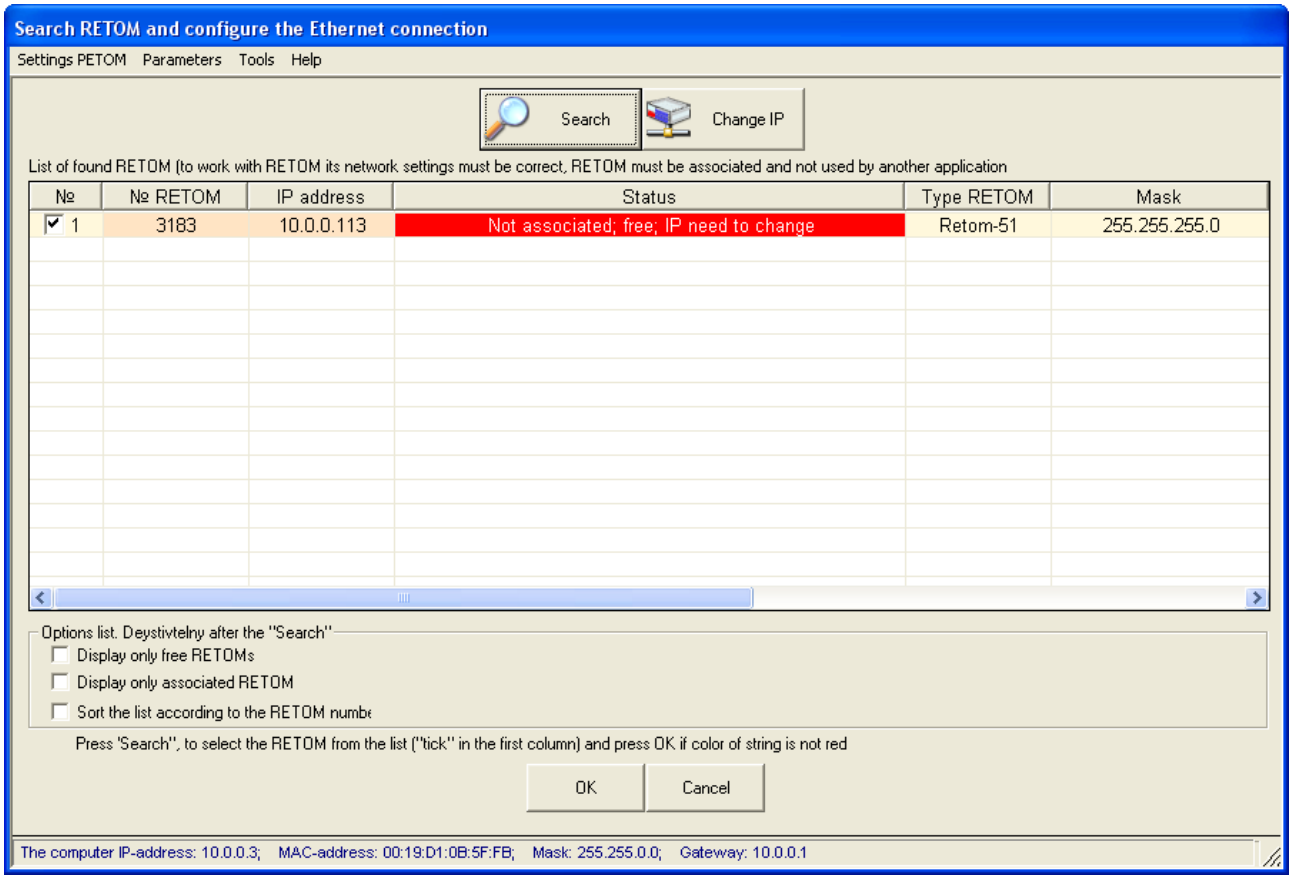


Figure 1.3.5 – Search utility and RETOM setting via Ethernet
(RETOM is associated with other PC)

- Close the search window.

1.3.2 Network Connection Setting at the Repeated Work Session of RETOM

No need in setting and searching. The settings are saved and you can start running of the RETOM software at once.

1.3.3 Search Window of RETOM Device

Let's examine the search window in detail (see Figure 1.3.6).

In the search dialog the list of the found RETOM devices is presented as a table with columns indicating the following parameters:

1. ordinal number;
2. serial number of RETOM;
3. IP address of RETOM (it should differ from the IP address of the PC connected to RETOM and from IP addresses of the other network computers, should not be equal to the gateway address and not ended by 0 but should be correct i.e. should be within the range of the enterprise network addresses. The computer IP address is in the string of the window status);

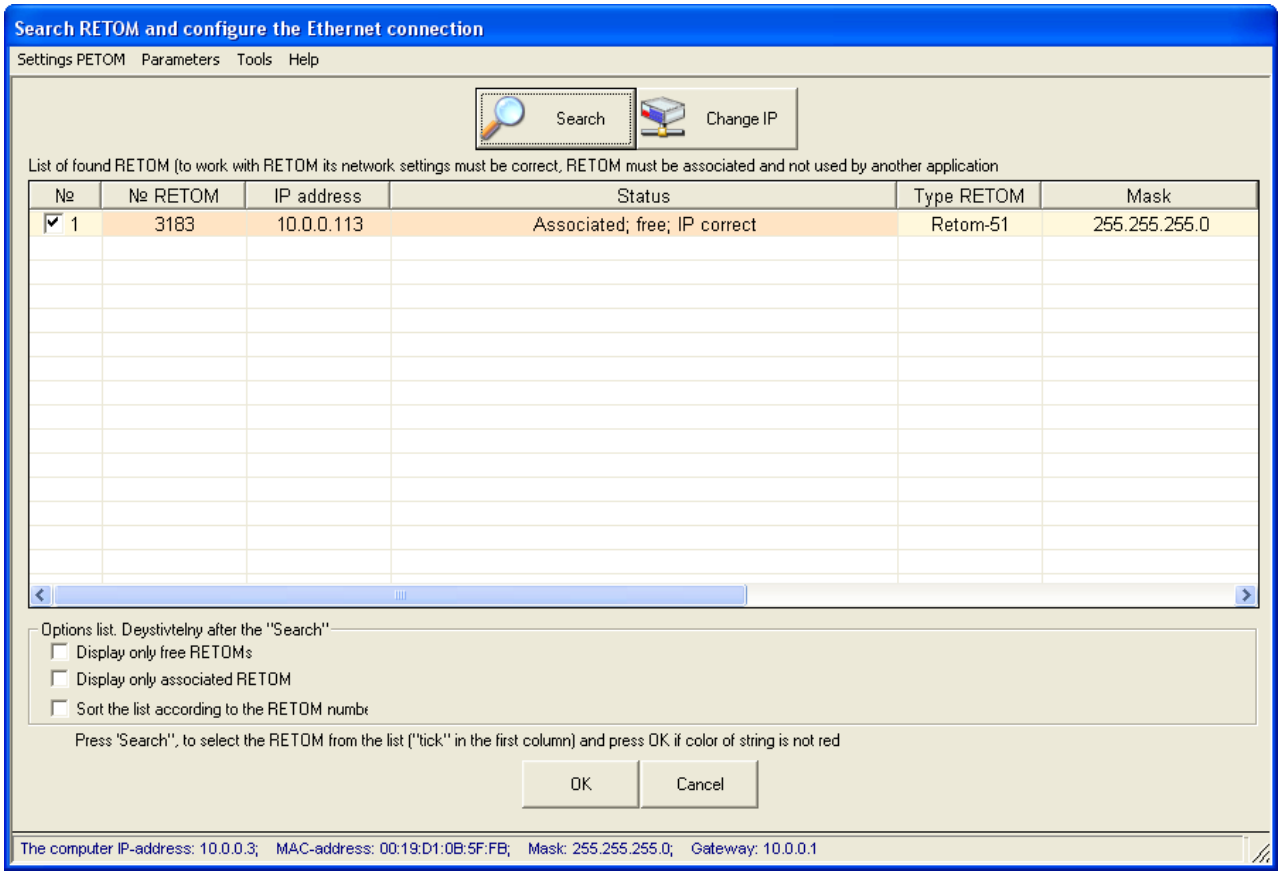

Search RETOM and configure the Ethernet connection
Settings PETOM
Parameters
Tools
Help
Search
Change IP
List of found RETOM (to work with RETOM its network settings must be correct, RETOM must be associated and not used by another application
№
№ RETOM
IP address
Status
Type RETOM
Mask
1
3183
10.0.0.113
Associated; free; IP correct
Retom-51
255.255.255.0
Options list. Deystivtelny after the "Search"
Display only free RETOMs
Display only associated RETOM
Sort the list according to the RETOM numbe
Press 'Search", to select the RETOM from the list ("tick" in the first column) and press OK if color of string is not red
OK
Cancel
The computer IP-address: 10.0.0.3; MAC-address: 00:19:D1:0B:5F:FB; Mask: 255.255.255.0; Gateway: 10.0.0.1

Figure 1.3.6 – RETOM device search window and communication setting via Ethernet

4. RETOM status (RETOM is ready to be operated when it is associated, i.e. «bound» to the given computer. No other computer can command RETOM until the association is made – physical confirmation of the communication by pressing the button “association” at the back panel of RETOM. The association process is described below. RETOM should be free, i.e. not occupied by other application. RETOM device network settings should be correct otherwise the communication is not possible. If even one of three conditions is ignored the communication with RETOM device is not possible. The column changes into red if the network settings are not correct and if the PC is not associated with RETOM device);
5. type of the device (RETOM-51 and etc.);
6. network mask (should be the same as in the PC, the PC mask is in the window status string);
7. gateway (it is not an obligatory parameter, generally the same as in the PC, gateway is in the window status string);
8. associated MAC-address of the PC (MAC-address is a unique digital code of 6 bytes for each device connected via Ethernet. So RETOM remembers the computer associated with. Other computers cannot connect with RETOM device, except search, even if it is free, until the association is made. MAC-address of the PC is displayed in the window status string);
9. MAC-address of RETOM device;
10. SW version.

In the search window status string the PC network settings are displayed (or of the selected one if there are several network adapters). In this case the network adapter search dialog appears first when the utility is started (see Figure 1.3.3). The network adapter search dialog can be called from the menu (Figure 1.3.7).

By pressing the button “Search” search process of RETOM devices is started (at this time the name of the button changes for “STOP” and the searching process can be broken by pressing this button. In the status string the searching indicator is displayed). The list of the found RETOM devices is filled. Only one device can be a selected device (when selecting a string in the list the first column should be ticked). The procedures of RETOM device settings changes are to be performed only by the selected RETOM.

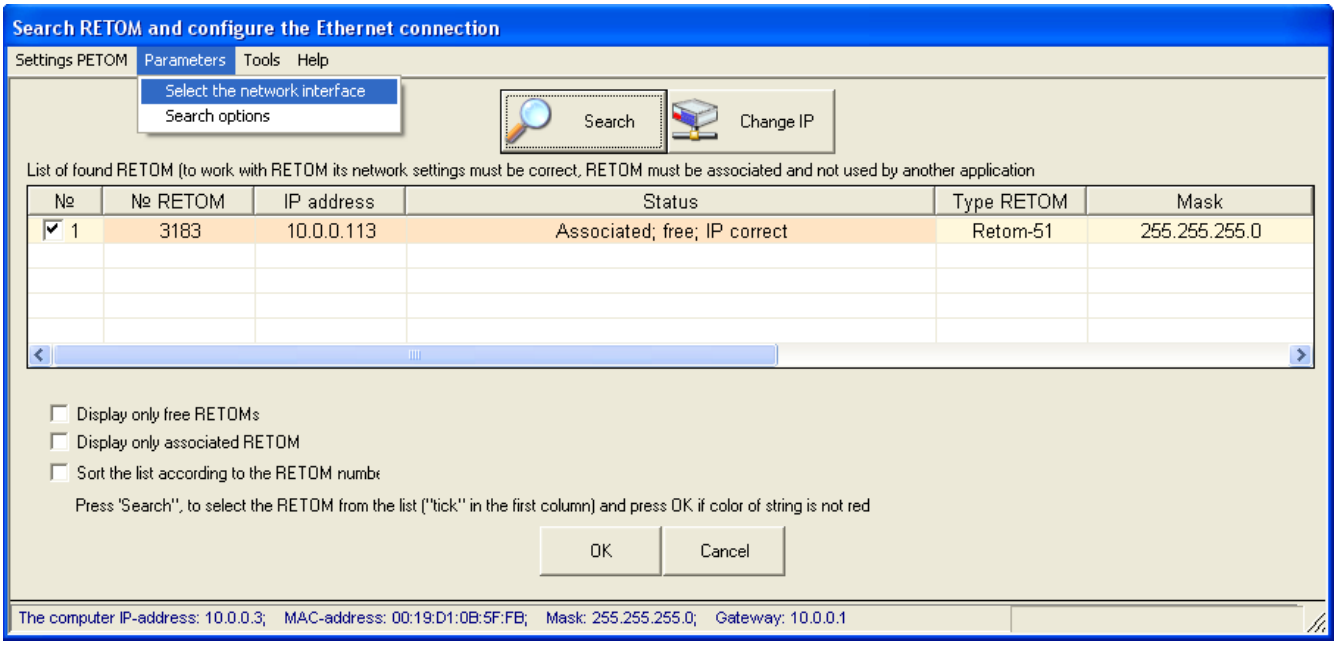

Search RETOM and configure the Ethernet connection
Settings PETOM
Parameters
Tools
Help
Select the network interface
Search options
Search
Change IP
List of found RETOM (to work with RETOM its network settings must be correct, RETOM must be associated and not used by another application
№
№ RETOM
IP address
Status
Type RETOM
Mask
1
3183
10.0.0.113
Associated; free; IP correct
Retom-51
255.255.255.0
Display only free RETOMs
Display only associated RETOM
Sort the list according to the RETOM numbe
Press 'Search", to select the RETOM from the list ("tick" in the first column) and press OK if color of string is not red
OK
Cancel
The computer IP-address: 10.0.0.3; MAC-address: 00:19:D1:0B:5F:FB; Mask: 255.255.255.0; Gateway: 10.0.0.1

Figure 1.3.7 – Menu item for selection of the network adapter

When selecting “Display only free RETOMs” and at a repeated search only included and free RETOM devices are entered into the list.

When selecting “Display only associated RETOM” and at a repeated search only included RETOM devices which have operated with this PC at the last session are entered into the list.

When selecting “Sort the list according to the RETOM number” and at a repeated search RETOM devices sorted according to the serial number are entered into the list.

By pressing the column heading you can sort the list as per the column.

The button “Change IP” calls RETOM network settings window (Figure 1.3.8 and 1.3.9).

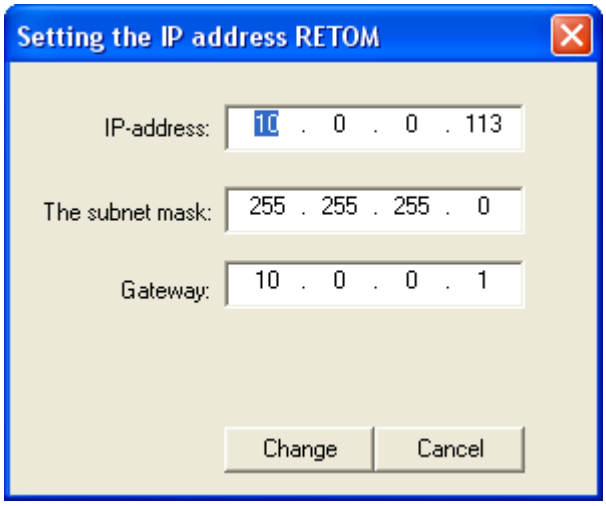


Figure 1.3.8 – RETOM network settings

When setting RETOM IP-address subnetwork mask and gateway should match.

IP-address of PETOM should not be equal to:

- the PC address (especially);
- addresses of other computers of the network;
- gateway address;
- should not end by 0.

Figure 1.3.9 – RETOM network settings confirmation window

Ethernet board is reloaded after the settings have been made so wait for 5 second before to continue.

The selected device software updating window can be called from the menu (see Figure 1.3.10). At this the software updating file selection window is opened (see Figure 1.3.11).

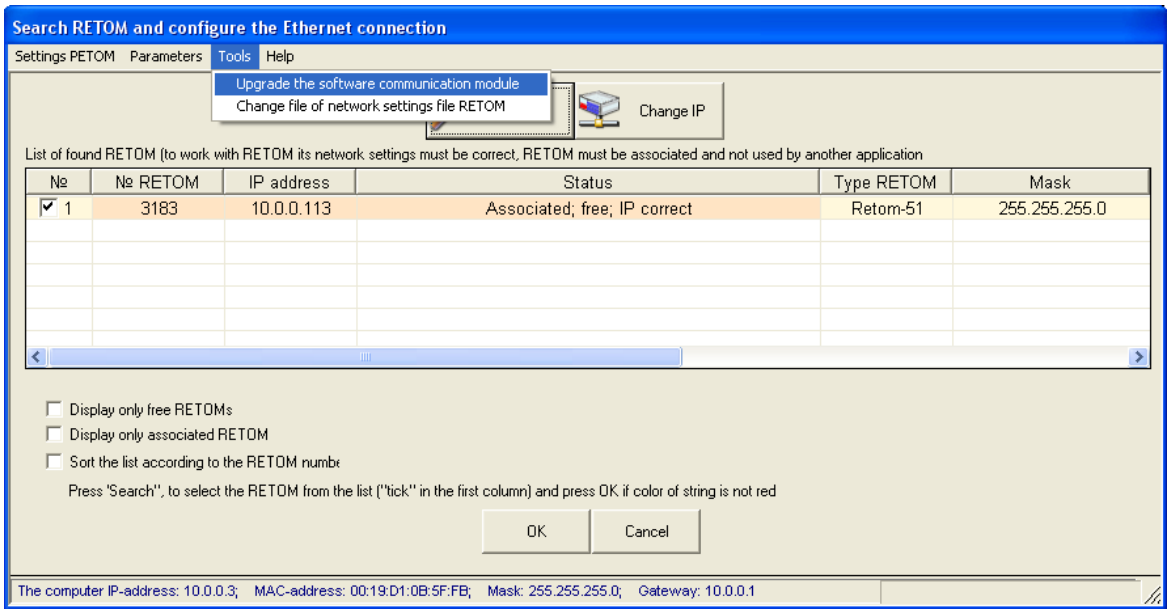

Search RETOM and configure the Ethernet connection
Settings PETOM
Parameters
Tools
Help
Upgrade the software communication module
Change file of network settings file RETOM
Change IP
List of found RETOM (to work with RETOM its network settings must be correct, RETOM must be associated and not used by another application
№
№ RETOM
IP address
Status
Type RETOM
Mask
1
3183
10.0.0.113
Associated; free; IP correct
Retom-51
255.255.255.0
Display only free RETOMs
Display only associated RETOM
Sort the list according to the RETOM numbe
Press 'Search'', to select the RETOM from the list (''tick'' in the first column) and press OK if color of string is not red
OK
Cancel
The computer IP-address: 10.0.0.3; MAC-address: 00:19:D1:0B:5F:FB; Mask: 255.255.255.0; Gateway: 10.0.0.1

Figure 1.3.10 – The menu item for calling the communication module software updating

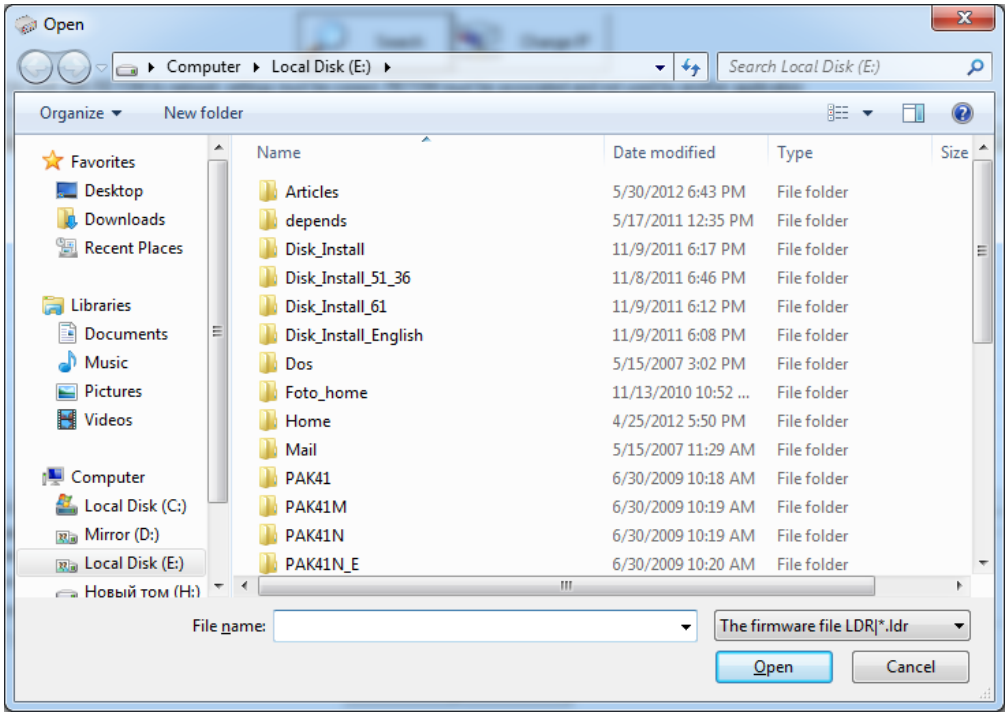


Figure 1.3.11 – Window Open the communication module SW updating file

1.3.3 RETOM Association Setting

Association is the PC binding to RETOM via MAC-address. Other computers can not communicate with RETOM device until the association is made – confirmation using button “Association” on RETOM.

Auto association – when the association is reset (set to nil) the computer communicating first with RETOM associates (binds) with RETOM.

Reset of the association – if the button “Association” on RETOM is pressed for 5 seconds the association is reset and network settings are set on default (IP-address 192.168.0.2, mask 255.255.255.0, gateway 192.168.0.1)

Communication of RETOM device with the PC is possible only if the PC is associated or the association is reset (set to nil).

The association can be reset by pressing the button “Association”. Then RETOM network settings can be adjusted as required for running with the given computer. I.e. when associating with the own PC or if the association is reset the IP-address can be changed.

While communication RETOM IP address and the PC IP address should not be equal but alike and their masks shall match. RETOM IP address should not be equal to the gateway address and should not end by 0. E.g, if the PC address is 10.0.0.3, RETOM IP address can be 10.0.0.2, i.e. it should differ by 1 in the lower byte. If the PC mask is 255.255.255.0 RETOM mask should be 255.255.255.0. The mask is needed to be laid on the IP address, and if in mask a byte is 255, RETOM device and PC IP addresses relevant bytes shall be equal. In our example it is 10.0.0, the last byte in the mask is not equal to 255 and so RETOM device and PC IP addresses should be different in this byte – in the example these are 2 and 3.

When the association is reset the computer which has communicated with RETOM first is autoassociated.

Association is kept in RETOM even after power has been off.

In order to associate RETOM (selected from the list after searching) with the PC select menu item *Settings RETOM – Associated with the computer* (Figure 1.3.12).

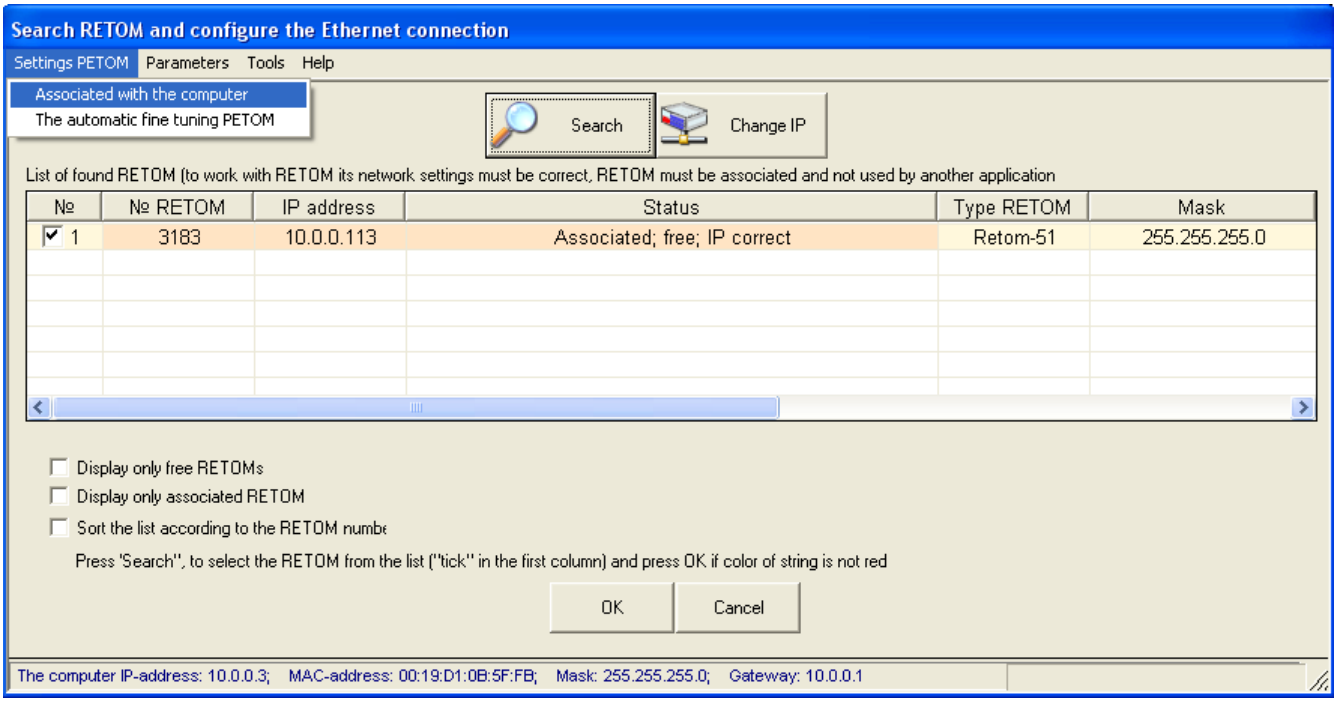

Search RETOM and configure the Ethernet connection
Settings PETOM
Parameters
Tools
Help
Associated with the computer
The automatic fine tuning PETOM
Search
Change IP
List of found RETOM (to work with RETOM its network settings must be correct, RETOM must be associated and not used by another application
№
№ RETOM
IP address
Status
Type RETOM
Mask
1
3183
10.0.0.113
Associated; free; IP correct
Retom-51
255.255.255.0
Display only free RETOMs
Display only associated RETOM
Sort the list according to the RETOM numbe
Press 'Search", to select the RETOM from the list ("tick" in the first column) and press OK if color of string is not red
OK
Cancel
The computer IP-address: 10.0.0.3; MAC-address: 00:19:D1:0B:5F:FB; Mask: 255.255.255.0; Gateway: 10.0.0.1

Figure 1.3.12 – Menu item of RETOM association

The window (Figure 1.3.13) appears, having pressed the confirmation of the intention to associate RETOM – Yes, press the button “Association” on RETOM device briefly and repeatedly for 10 seconds (but one press shall not be more than for 5 seconds otherwise RETOM network settings will be reset).

If the association is successful the confirmation window (Figure 1.3.14) will appear, or the window shown in Figure 1.3.15 if different.

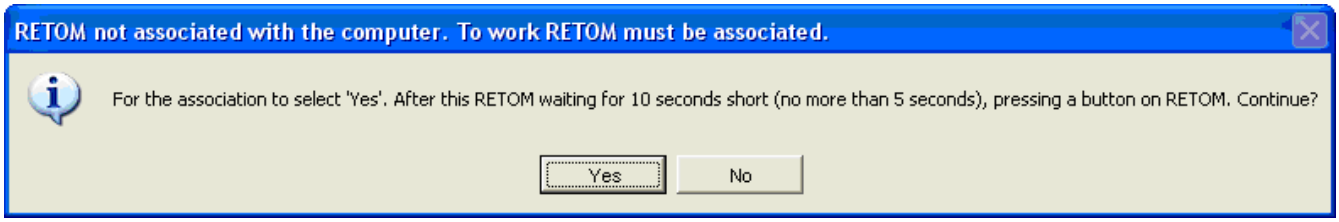

RETOM not associated with the computer. To work RETOM must be associated.
For the association to select 'Yes'. After this RETOM waiting for 10 seconds short (no more than 5 seconds), pressing a button on RETOM. Continue?
Yes
No

Figure 1.3.13 – RETOM association inquiry

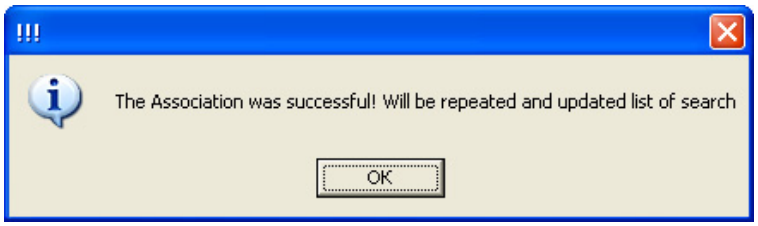


Figure 1.3.14 – RETOM successful association confirmation

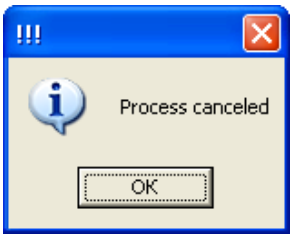


Figure 1.3.15 – This window appears in case if RETOM association is not successful

RETOM autosetting can be used when connected RETOM device to the PC without connecting to the shared network (in point-to-point mode when Ethernet cable is connected directly with the PC). In this case all of RETOM device network settings adjust automatically to the PC network settings (IP address differs by 1 – they should differ, but MAC address and gateway address should be the same). Ethernet board reloads after having been set, so wait for 5 seconds before to continue. After RETOM has been set automatically you can start working with the program. Please note, that when connecting to the enterprise shared network you'd better consult with the enterprise system administrator on setting RETOM IP address to free IP address (as there might be problems connected with communication as for RETOM as well as for PC due to same IP address). RETOM network parameters setting – see Figures 1.3.8 and 1.3.9.

For RETOM autosetting select menu item *Settings RETOM – The automatic fine tuning RETOM* (Figure 1.3.16).

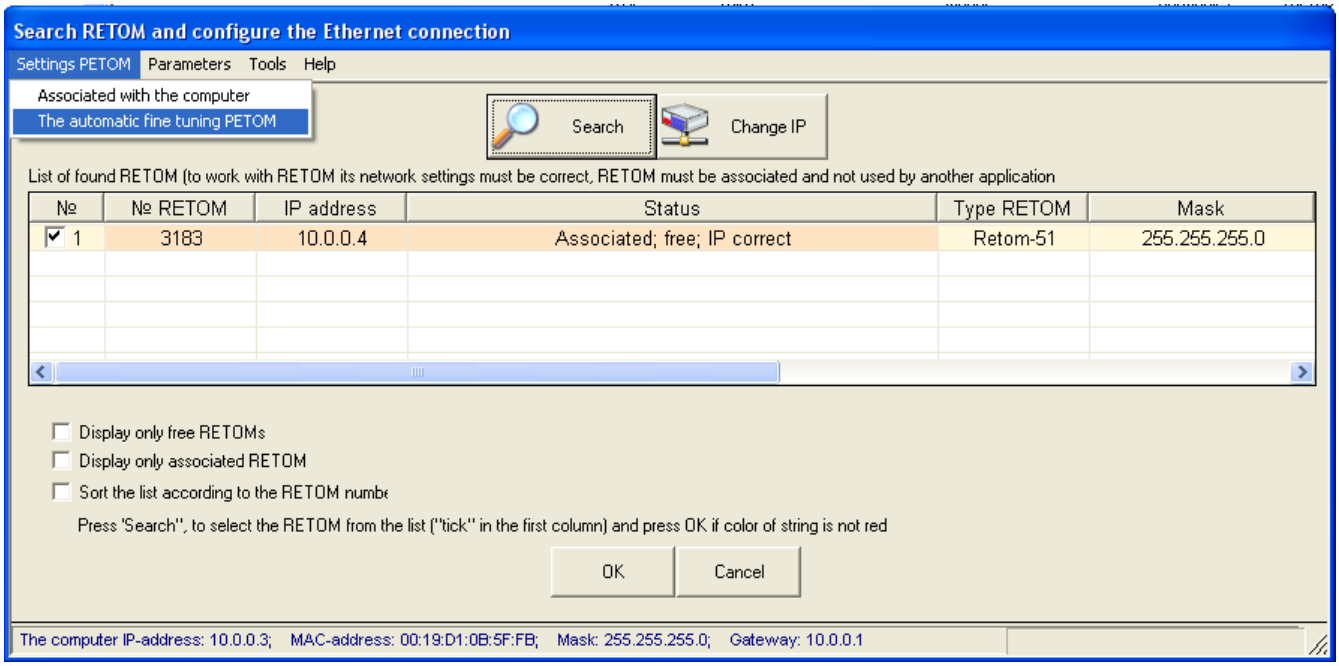

Search RETOM and configure the Ethernet connection
Settings PETOM
Parameters
Tools
Help
Associated with the computer
The automatic fine tuning PETOM
Search
Change IP
List of found RETOM (to work with RETOM its network settings must be correct, RETOM must be associated and not used by another application
№
№ RETOM
IP address
Status
Type RETOM
Mask
1
3183
10.0.0.4
Associated; free; IP correct
Retom-51
255.255.255.0
Display only free RETOMs
Display only associated RETOM
Sort the list according to the RETOM numbe
Press 'Search'', to select the RETOM from the list (''tick'' in the first column) and press OK if color of string is not red
OK
Cancel
The computer IP-address: 10.0.0.3; MAC-address: 00:19:D1:0B:5F:FB; Mask: 255.255.255.0; Gateway: 10.0.0.1

Figure 1.3.16 – Menu item to call RETOM autosetting

If the autosetting is successful the confirmation window will appear (Figure 1.3.17), and the update list with the changed RETOM network settings will be displayed in the window (Figure 1.3.18).

Figure 1.3.17 – Confirmation of the successful autosetting

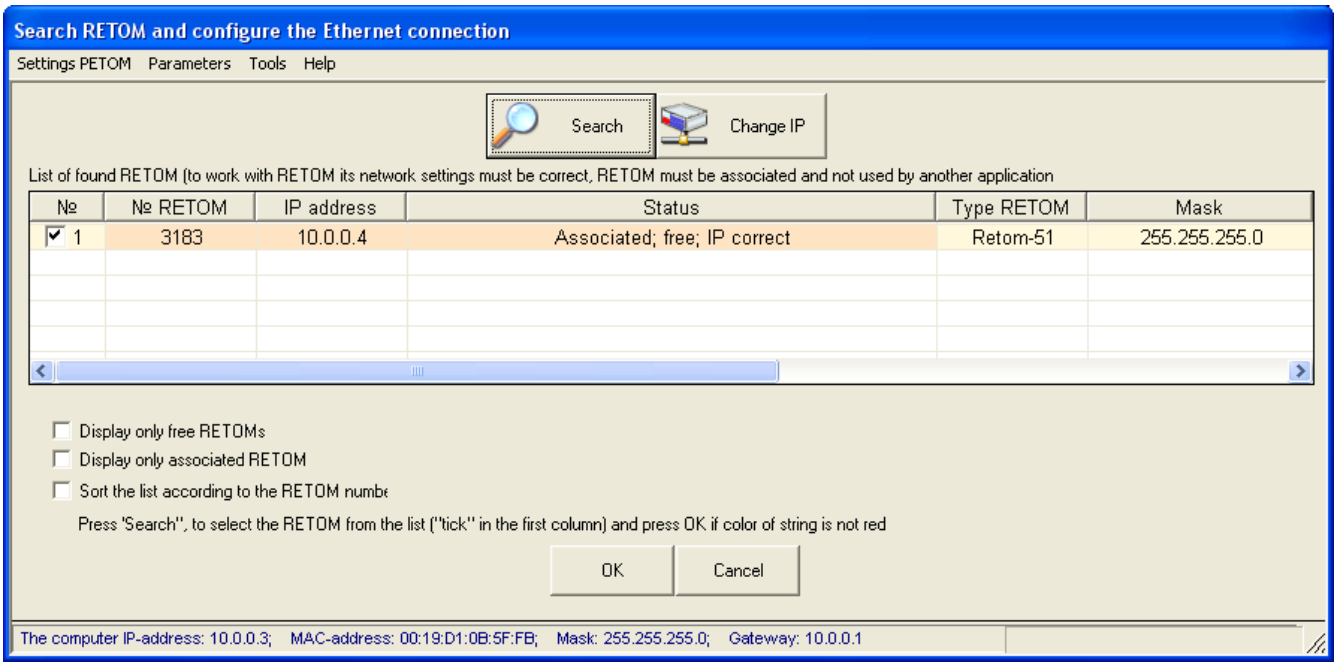

Search RETOM and configure the Ethernet connection
Settings PETOM
Parameters
Tools
Help
Search
Change IP
List of found RETOM (to work with RETOM its network settings must be correct, RETOM must be associated and not used by another application
№
№ RETOM
IP address
Status
Type RETOM
Mask
1
3183
10.0.0.4
Associated; free; IP correct
Retom-51
255.255.255.0
Display only free RETOMs
Display only associated RETOM
Sort the list according to the RETOM numbe
Press 'Search'', to select the RETOM from the list (''tick'' in the first column) and press OK if color of string is not red
OK
Cancel
The computer IP-address: 10.0.0.3; MAC-address: 00:19:D1:0B:5F:FB; Mask: 255.255.255.0; Gateway: 10.0.0.1

Figure 1.3.18 – Updated list with the changed RETOM network settings after the autosetting has been finished

2 Connecting Several RETOM-51 Devices to One Computer

Simultaneous operation of up to 9 RETOM-51 devices with one computer is software-implemented. Actually the number of RETOM-51 devices s is limited by computer performance. Usually operation of 2 or 3 program copies is no problem, this is what actually required is. Each program copy dealing with “own” device works independent of other RETOM-51. All necessary settings (coefficient tables etc.) are saved in RETOM-51. Changeover among windows is the same as in Windows.

2.1 Start of Several Devices

To start second (and subsequent) program copy click RETOM-51 program icon one more time. Window warning about 2nd (3rd) program start will appear (see Figure 2.1.1). After closing this window you will see one more program window showing the copy serial number at header (see Figure 2.1.3).

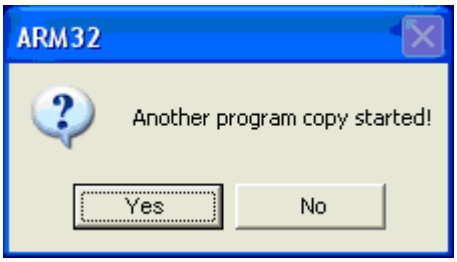


Figure 2.1.1 – Message when starting subsequent program copies

When program switch is turned on in each program copy, a dialog for communication channel selection appears irrespective of option setting *“Show additional setting windows when starting the program”*.

Connecting of several RETOM-51 devices via Ethernet ports is to be performed in accordance with Section 1 (point 1.3) selecting a device from the list as per the serial number and setting its IP address if required.

When connecting via USB channel at first start of every RETOM “new” for a given computer, wait for equipment installation wizard appear and repeat communication driver installation procedure for these RETOM-51 devices (this procedure is described in Section 1 (point 1.2)).

Generally a computer has 2 or more USB ports. Having selected USP port press *OK* - communication channel selection dialog will be redrawn showing a list of RETOM-51 devices numbers connected to USP channels (Figure 2.1.2). Connected RETOM-51 devices will be shown in the list as “busy”. After selection of a free RETOM-51 number and closing communication channel selection dialog, computer will connect next RETOM-51 device and issue resulting message.

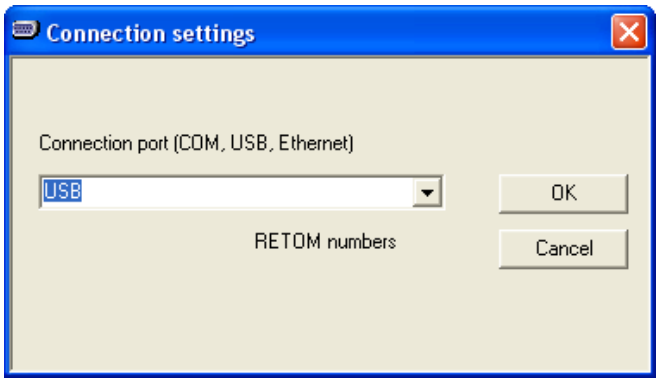


Figure 2.1.2 – USP port setup

After successful connecting PC to RETOM-51 an additional window with program copy number and connected RETOM-51 number will appear in main window header (for unambiguous match of each program copy and RETOM-51) (see Figure 2.1.3.).

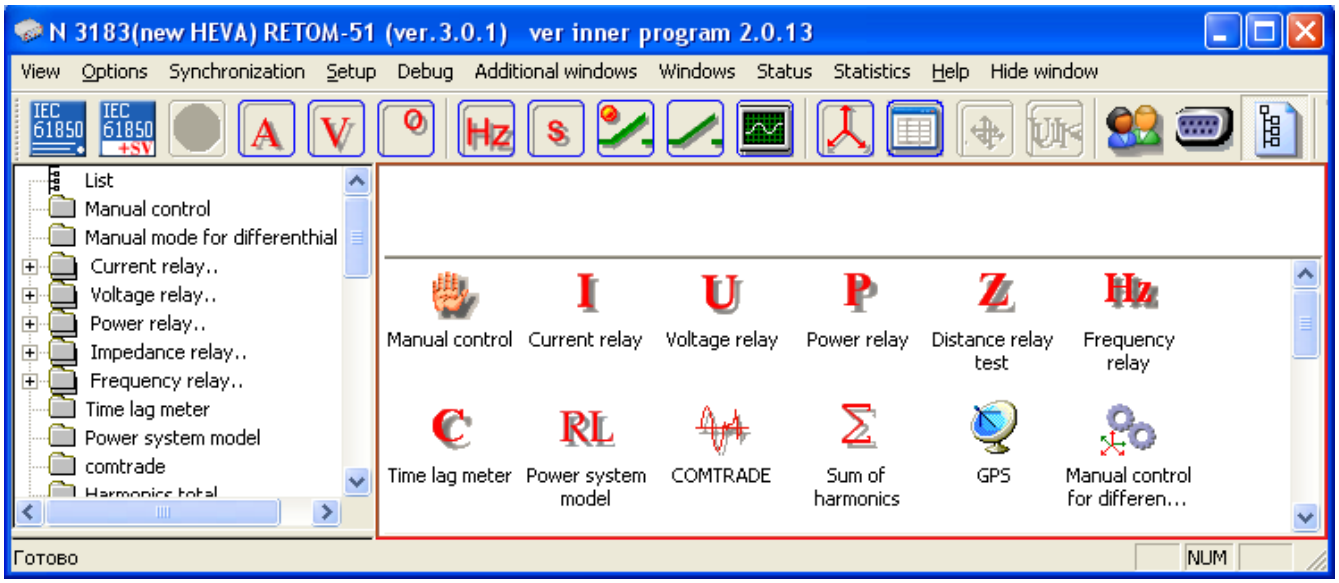


Figure 2.1.3 – Window header after connecting to the second RETOM-51 (serial number №3183)

2.2 RETOM-51 Devices Synchronization

RETOM-51 is provided with mains synchronization, RETOM-51 devices synchronization with each other (one master and several slaves) and autotest by external start through RETOM-51 binary input. RETOM-51 devices synchronization with each other is irrelevant to a computer and can be performed when operating one or several computers.

Mains synchronization (see Figure 2.2.1) is performed either through mains voltage supplied via RETOM power supply plug or through binary input 8 (through synchronization block – adapter).Correct synchronization depends on position of adapter plug in the socket: the directed plug pin must be related to phase, not ground). In case of wrong synchronization switch RETOM off and turn the power supply plug. RETOM-51 mains synchronization is only provided for analog values by angle bound to mains voltage angle. All other RETOM-51 actions (e.g. time lag meter start, automatic test start) are not synchronized at all.

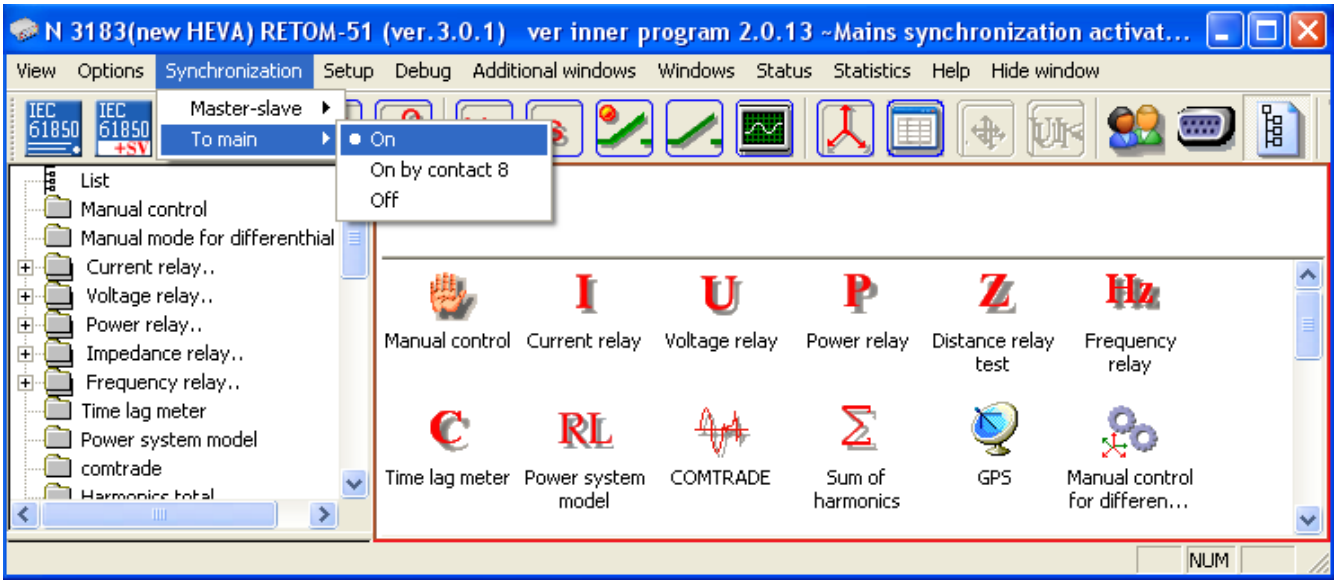


Figure 2.2.1 – Mains synchronization

Master/slave mode (Figure 2.2.2) supposes synchronous start of both RETOM-51 devices (i.e. synchronization of events occurs). Slave must be started first (several slaves possible); it will wait for Master command to start. This mode allows both manual mode operation and operation of any automatic programs realizing certain actions synchronously.

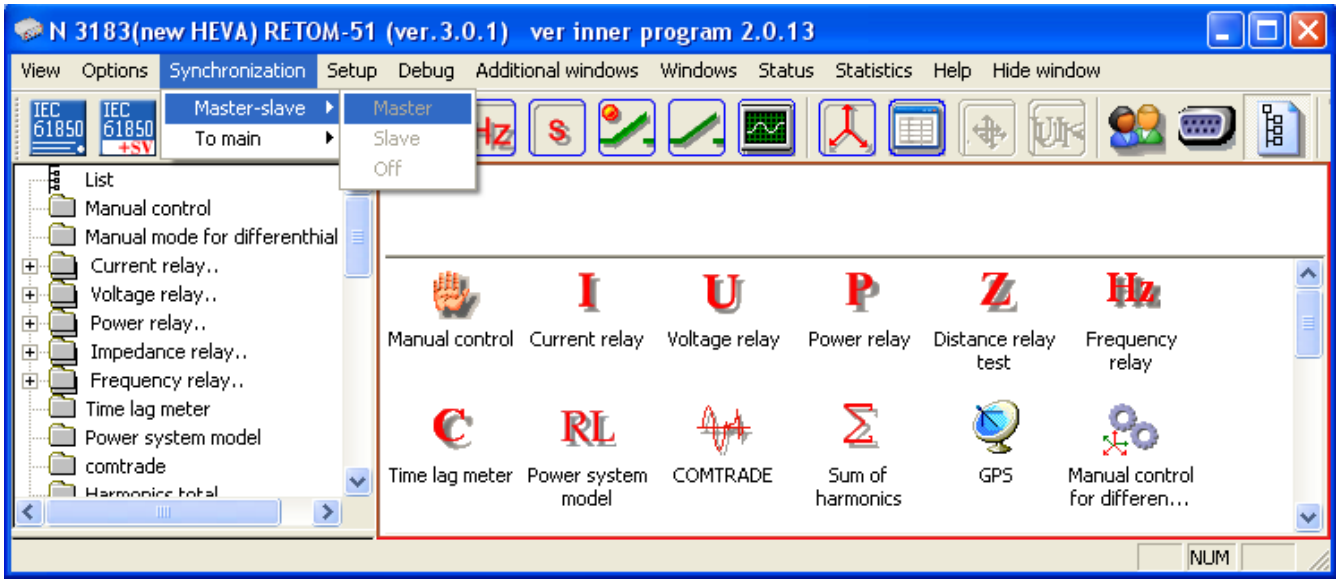
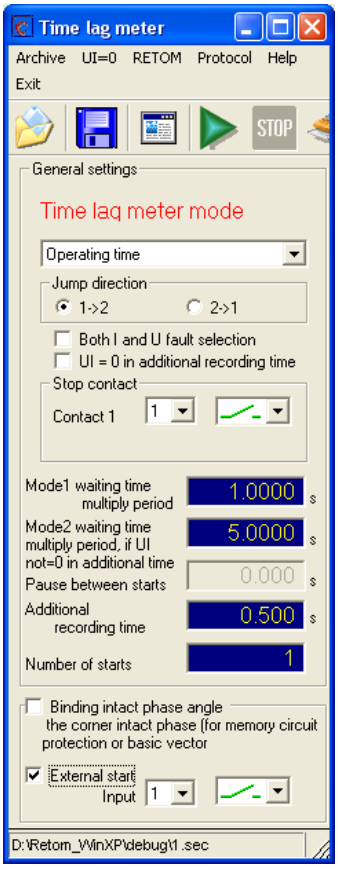


Figure 2.2.2 – Master/Slave synchronization

External start is provided in following programs: *Time lag meter, Simulation of fault process recorded in COMTRADE-format, Sum of harmonics – definition of arbitrary shaped signals, Power system RL-model and Currents and voltages signal drawing*. External start setup is performed in each program individually (see Figure 2.2.3). In *External start mode* set *External start* flag, select RETOM-51 input number and contact type for start. Tests are started as during an ordinary start, but delivery of voltages and currents is delayed until external confirmation is received through the input selected from external contact. In case of a long (over 10 seconds) continuous process signal angle discrepancy between different RETOM-51 devices is possible. In case of shorter time this discrepancy can be neglected.



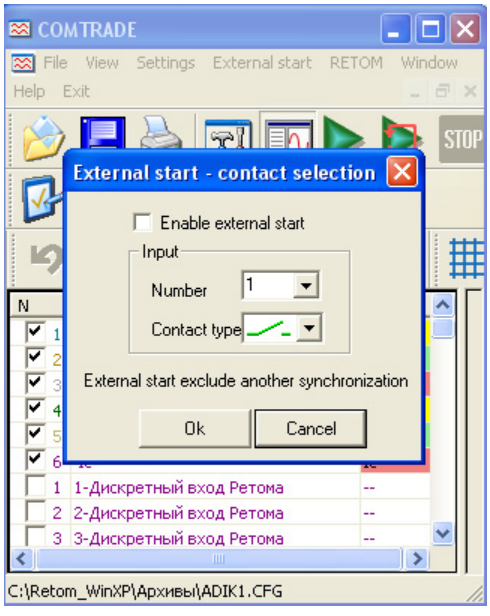


Figure 2.2.3 – External start setup

When the programs *Sum of harmonics, Power system RL-model* or *Currents and voltages signal drawing* are used external start setup is performed by *External start* menu item in a manner like *Simulation of fault process recorded in COMTRADE-format* setup (see Figure 2.2.3).

Mains synchronization and *Master/Slave synchronization* modes are selected from program main menu. Selection has to be performed before a test start. *Mains synchronization* menu item is duplicated also at *Manual control* program menu (see Figure 2.2.4).

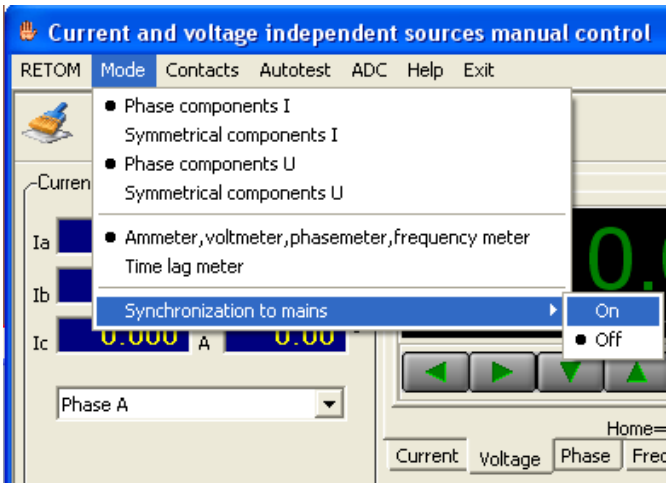


Figure 2.2.4 – *Mains synchronization* setup in *Manual control* program

2.3 RETOM-51 Hardware Synchronization

For *Mains synchronization* RETOM-51 plug power supply phase pin is marked by a dot. The cable is in this respect unique, so when using another cable (not marked) it is required to check phasing and turn the plug if necessary. Correct RETOM/phase connection can be checked based on either protection operation analysis or by galvanically isolated double-beam oscilloscope (otherwise RETOM-51 failure is possible): one beam is from mains, the other one from RETOM-51 (U_A – phase A voltage). When zero angle is set for U_A voltage, two oscilloscope beams will be displayed either in phase or in antiphase. If the U_A voltage is in antiphase with mains, it is possible either to consider this difference of 180^0 or switch RETOM-51 off (having exited the program first) and turn RETOM power supply plug.

For *Master/Slave synchronization* a special cable connecting RETOM-51 devices synchronization outputs must be used (see RETOM-51 Operation Manual, Section 8): Master RETOM-51 “+” synchronization output must be connected to Slave “+” synchronization input, Master “-“ synchronization output must be connected to Slave “-“ synchronization input. In case more than two RETOM-51 devices are to be connected, synchronization outputs of the Slave (which is already connected to Master according to previously described procedure) must be connected to second Slave RETOM -51 inputs, i.e. to make “through channel”.

3 RETOM-51 Program Package

3.1 Main Window

RETOM-51 main window with setup and test programs are shown in Figure 3.1.1. The upper part of the window contains the menu bar, which includes the following: *View, Options, Synchronization, Setup, Debug, Additional windows, Windows, Status, Help.*

View and *Options* menu items are shown in Figure 3.1.1.

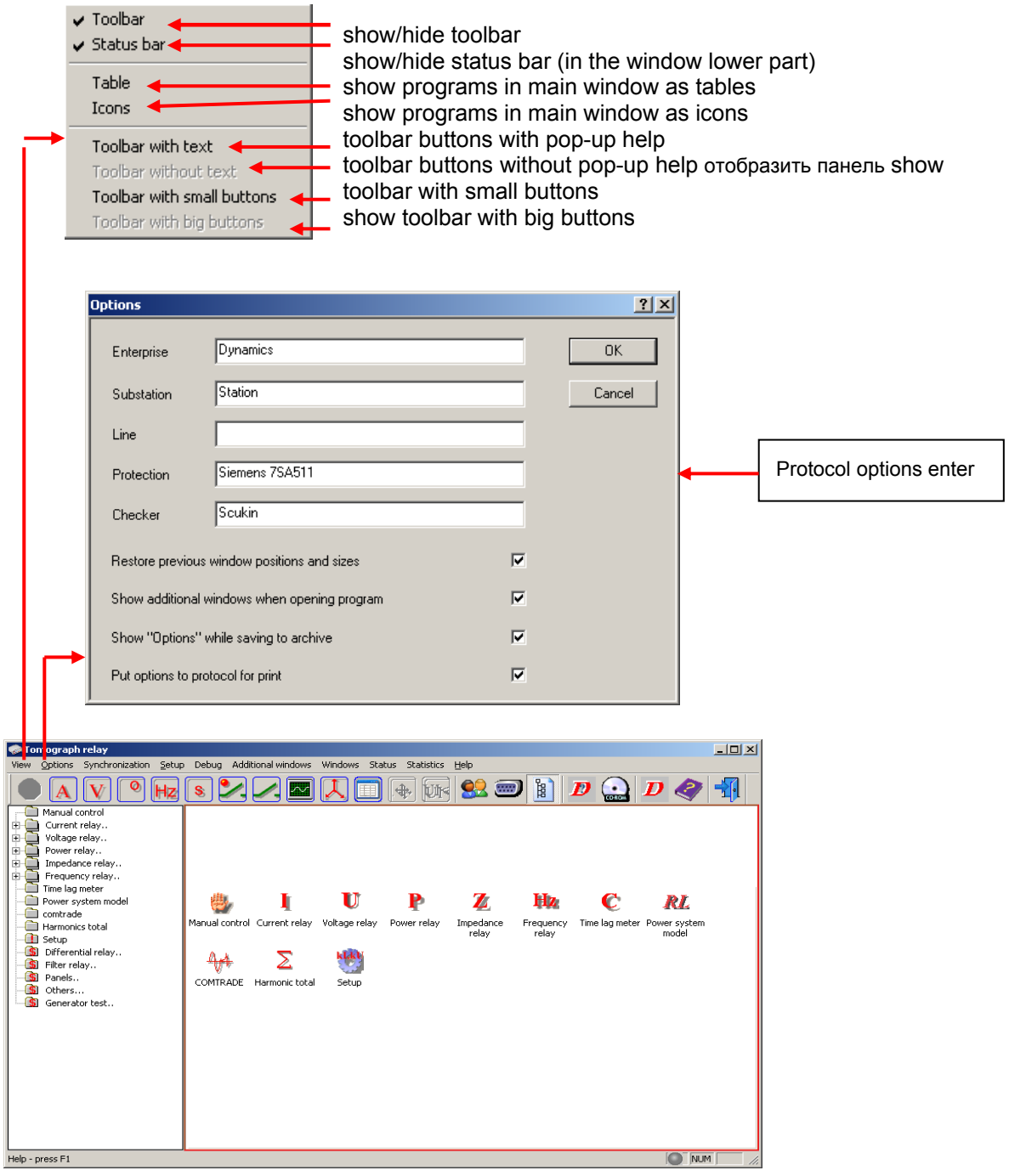


Figure 3.1.1 *View* and *Options* menu items

Setup menu item is shown in Figure 3.1.2.

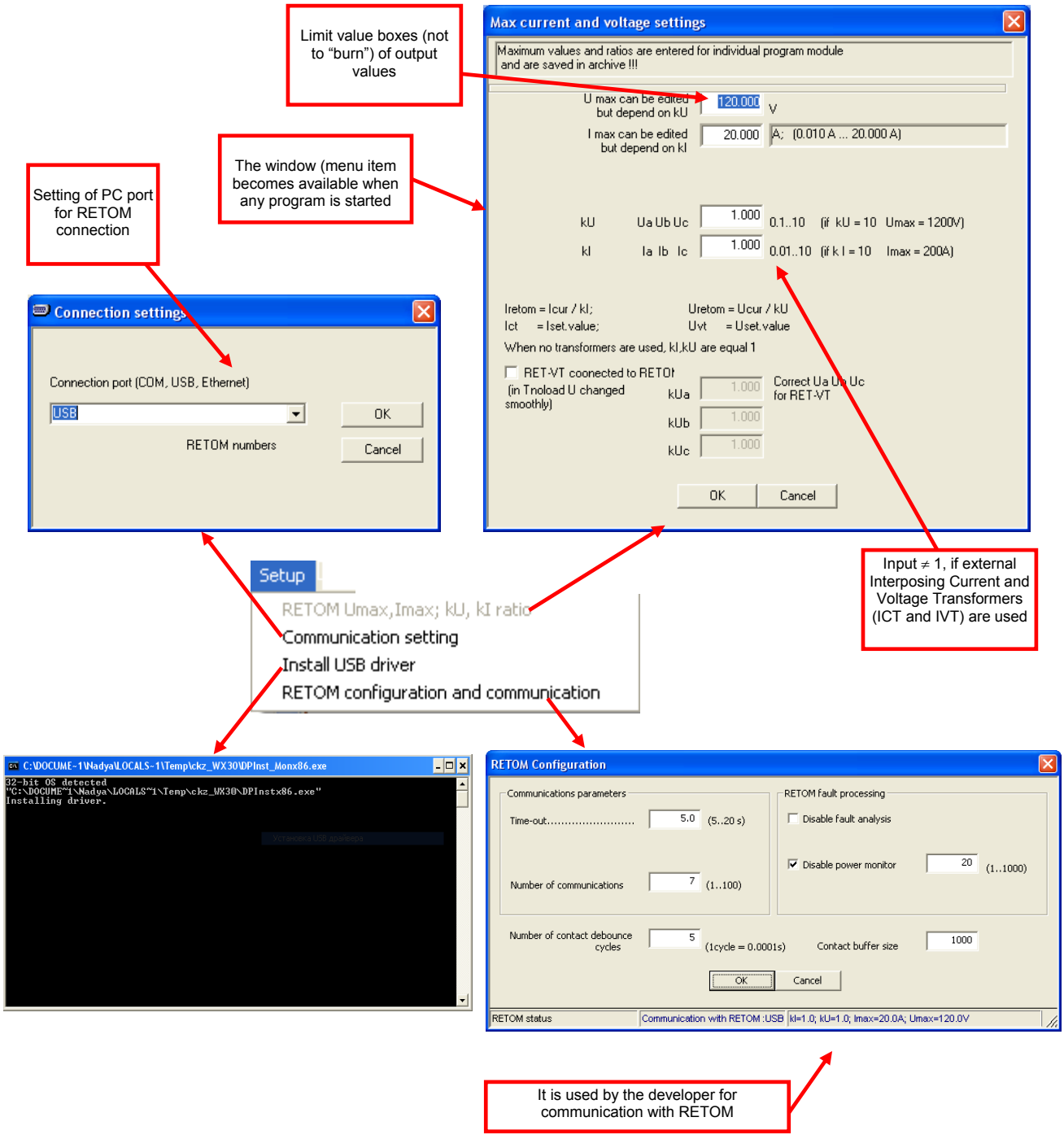


Figure 3.1.2 – *Setup* menu item

Debug menu item is used by RETOM-51 and is not user accessible;
Additional Windows menu item is shown in Figure 3.1.3.

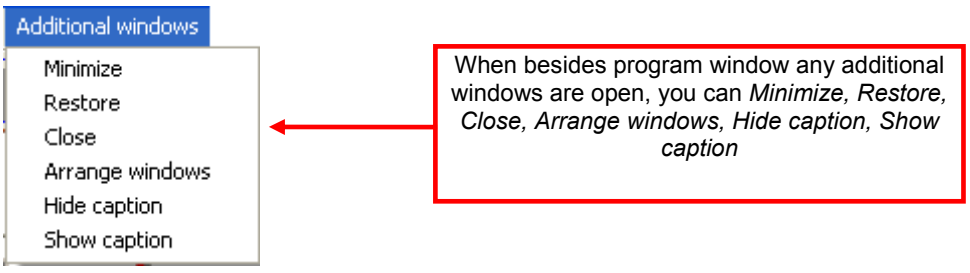


Figure 3.1.3 – *Additional Windows* menu item

Windows menu item has two functions: *Restore defaults while opening a window* - restores default window size and position displayed; *Redraw windows* - updates windows;

Status menu item is shown in Figure 3.1.4. Opens status window, i.e. displays RETOM current state system information, options information etc.

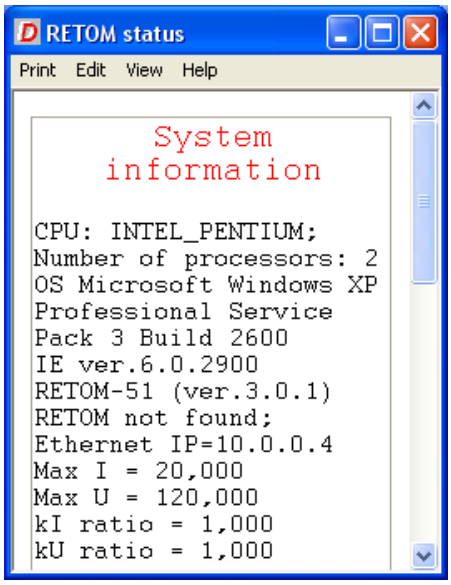


Figure 3.1.4 – *Status* menu item

Help menu item - opens *Help service*.

Toolbar buttons are below the menu bar.

Figures 3.1.5 – 3.1.9 show Toolbar button designation.

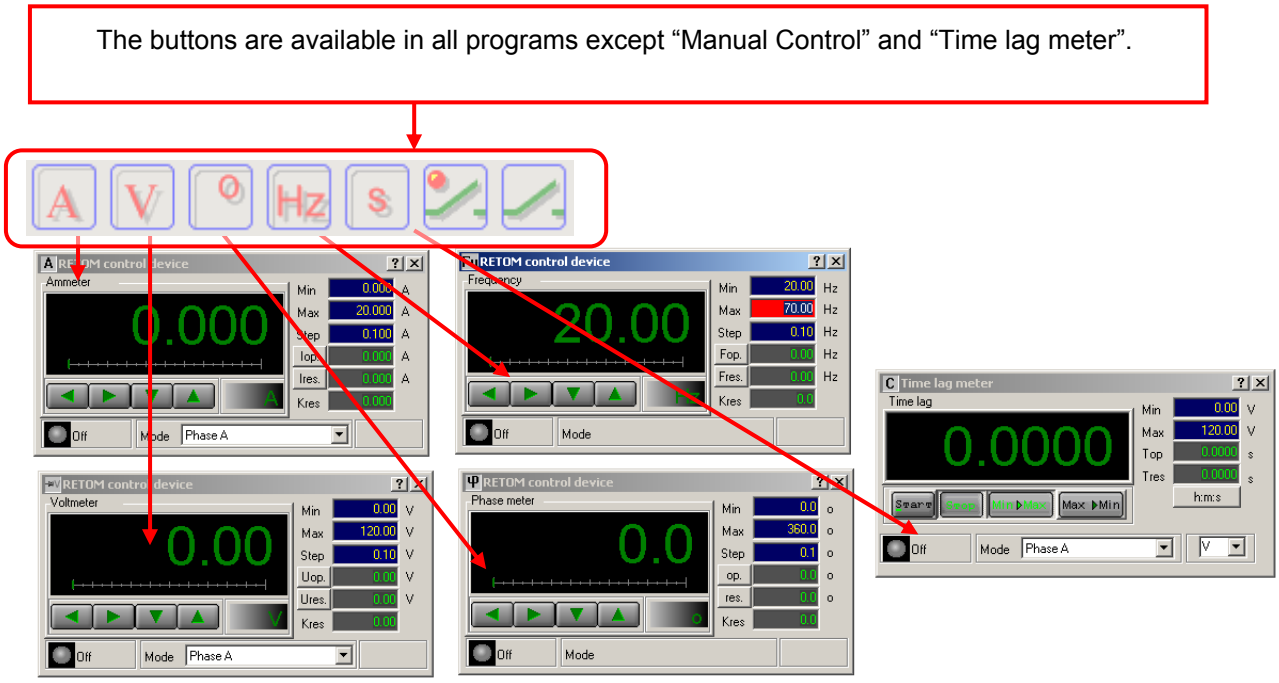


Figure 3.1.5 – Virtual control devices of current and voltage sources

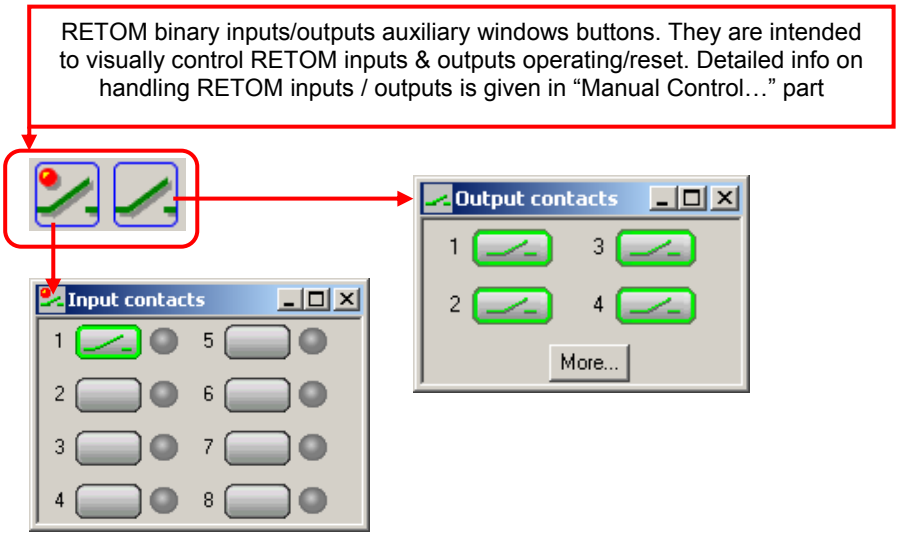
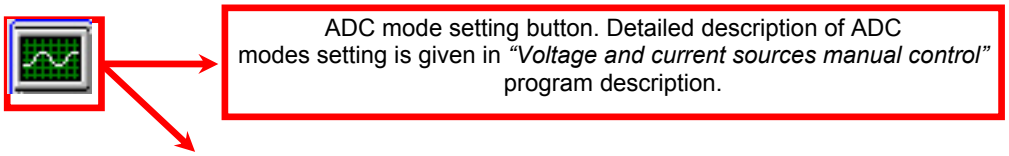


Figure 3.1.6 – Binary inputs/outputs auxiliary windows buttons


ADC mode setting button. Detailed description of ADC modes setting is given in “Voltage and current sources manual control” program description.

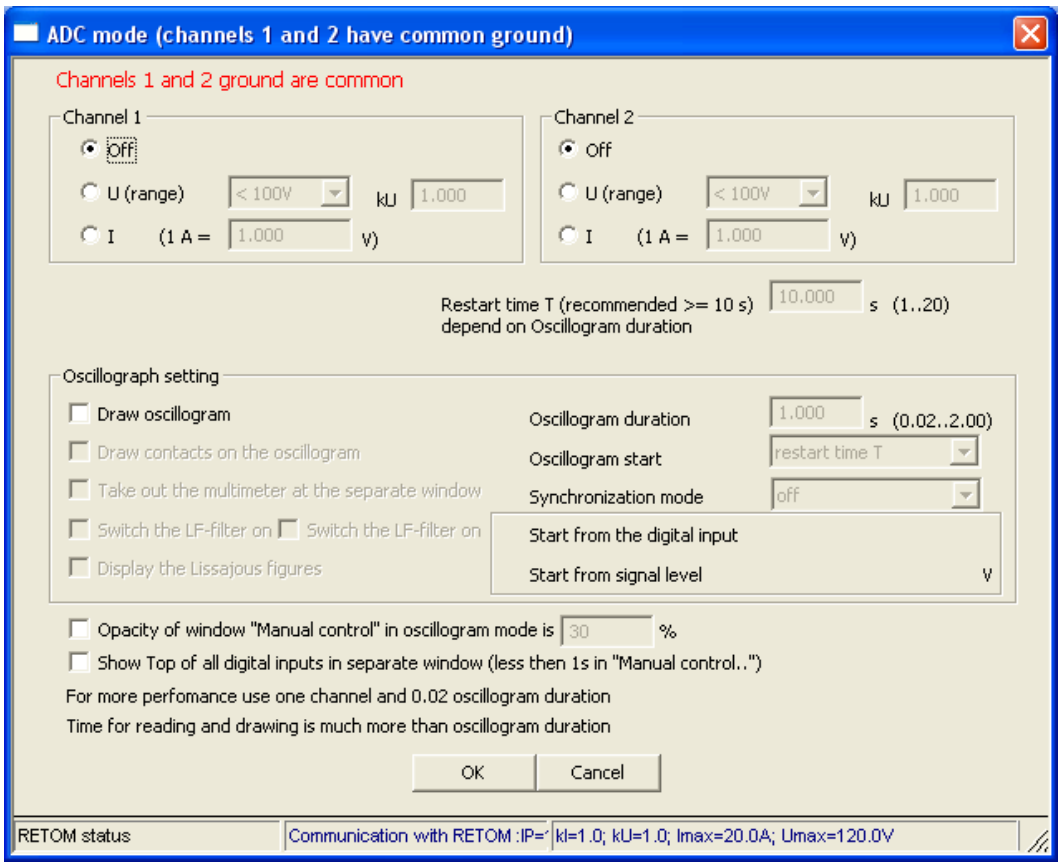


Figure 3.1.7 – ADC mode setting button (analog signals)

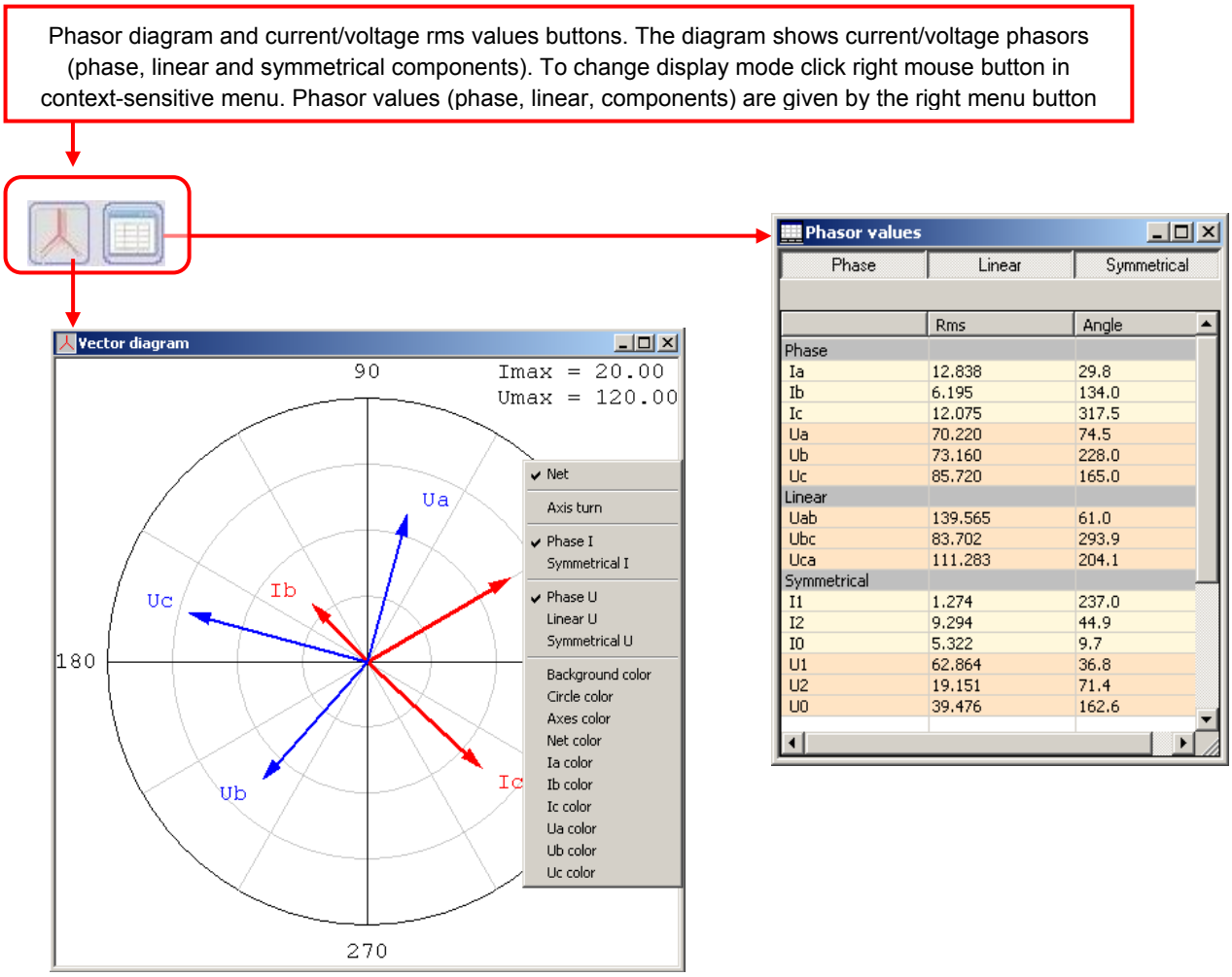


Figure 3.1.8 – Vector diagram window and active values window buttons

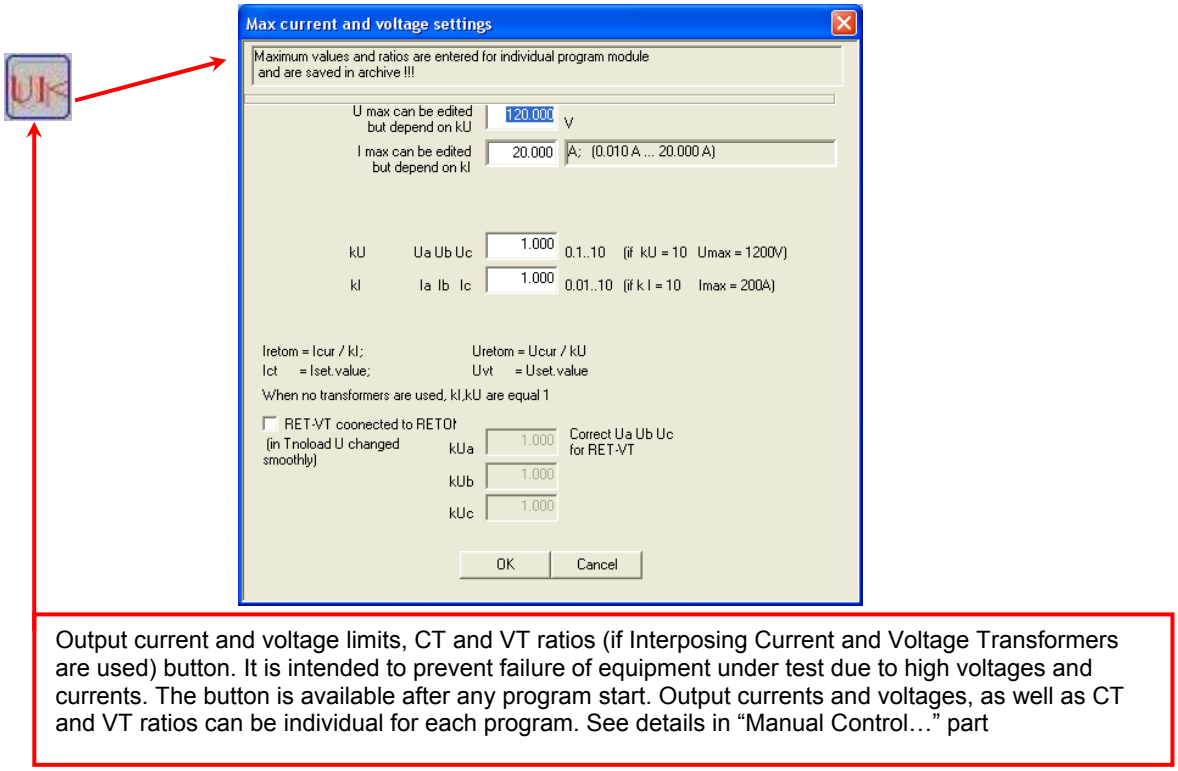

Max current and voltage settings
Maximum values and ratios are entered for individual program module and are saved in archive !!!
U max can be edited but depend on kU
120.000
V
I max can be edited but depend on kI
20.000
A; (0.010 A ... 20.000 A)
kU Ua Ub Uc
1.000
0.1..10 (if kU = 10 Umax = 1200V)
kI Ia Ib Ic
1.000
0.01..10 (if kI = 10 Imax = 200A)
Iretom = Icur / kI;
Ict = Iset.value;
Uretom = Ucur / kU
Uvt = Uset.value
When no transformers are used, kI,kU are equal 1
RET-VT coonected to RETOt
(in Tnoload U changed smoothly)
kUa
kUb
kUc
1.000
Correct Ua Ub Uc for RET-VT
OK
Cancel
Output current and voltage limits, CT and VT ratios (if Interposing Current and Voltage Transformers are used) button. It is intended to prevent failure of equipment under test due to high voltages and currents. The button is available after any program start. Output currents and voltages, as well as CT and VT ratios can be individual for each program. See details in “Manual Control…” part

Figure 3.1.9 – Output current and voltage limits button

<*Options*> button to set protocol parameters (See details in “Manual Control…” part). <*Communication setting*> button (See menu description) and main window view control button are shown in Figure 3.1.10.

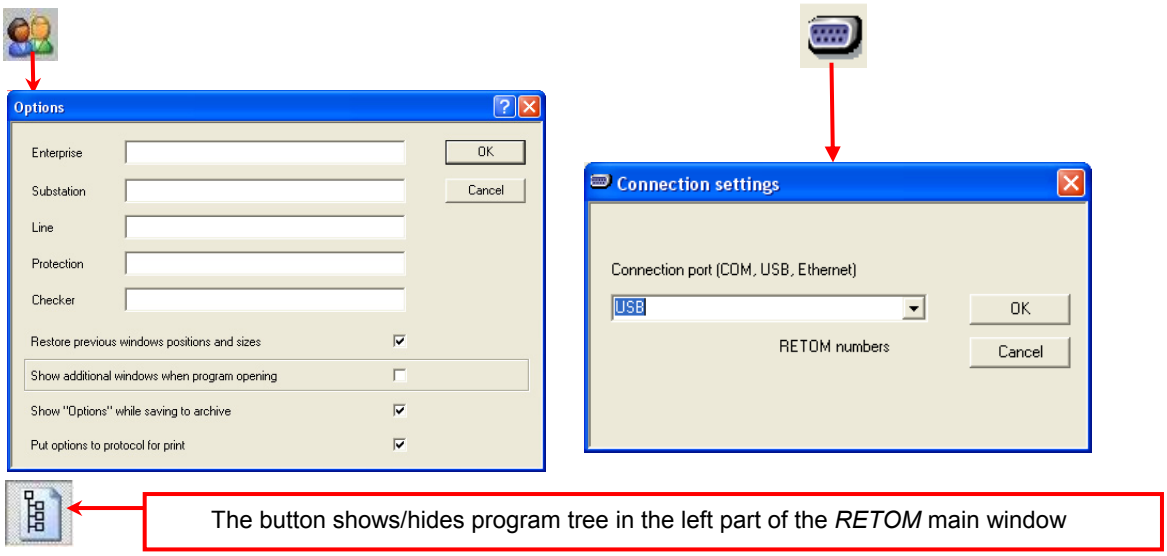


Figure 3.1.10 – *Options, Communication setting* and main window view control buttons

Help and *Exit* buttons are shown in Figure 3.1.11.

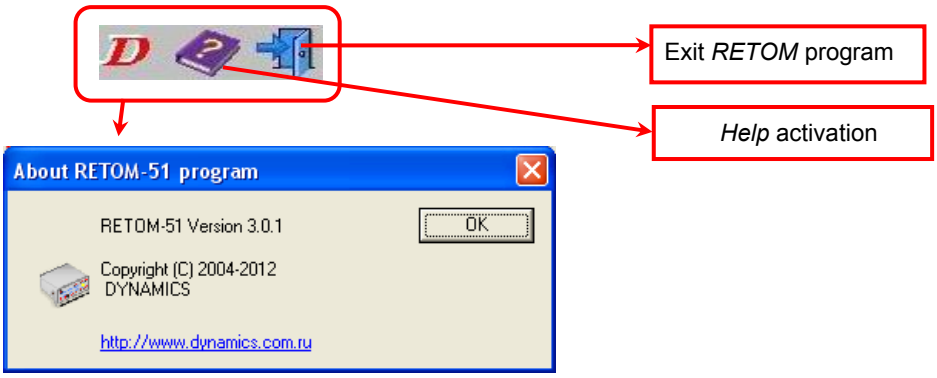


Figure 3.1.11 – *About*, *Help* and *Exit* buttons

RETOM-51 standard package includes the following programs:

- Voltage and current independent source manual controll
- Automatic current relay test;
- Automatic voltage relay test;
- Automatic power direction relay test;
- Automatic impedance relay test;
- Automatic frequency relay test;
- Time-lag meter;
- Power system RL-model;
- Simulation of fault process recorded in COMTRADE-format;
- Sum of harmonics – definition of arbitrary shaped signals;
- Manual control of current sources for differential protection test;
- RETOM-51 setup, adjustment and correction program.

3.2 RETOM-51 Setup, Adjustment and Correction Program

3.2.1 Application

The program is intended to adjust the gain factor of RETOM-51 voltage and current channels at specified current, voltage and load values. It is also designed for output voltage and current phase error compensation, unbalance reduction of voltage and current amplifiers and analog input (ADC) compensation.

Sinusoidal voltage and current instantaneous values are calculated according to:

$$a(t) = k_a \sqrt{2} A \sin(2\pi f t + \varphi + \Delta\varphi) \pm A_{UNB}, \quad (3.1)$$

where the following values are set and compensated by the adjustment program:

k_a – rms value (current or voltage) compensation factor;

$\Delta\varphi$ – current or voltage phase angle offset compensation;

A_{UNB} – current or voltage offset compensation.

3.2.2 Program Start

To start the program in the RETOM-51 main window the icon *Setup* is used.

On setup program start the password enter box appears. RETOM-51 factors determine its measuring precision and in order to prevent unauthorized factor changing the User must enter Password: (see Figure 3.2.1).

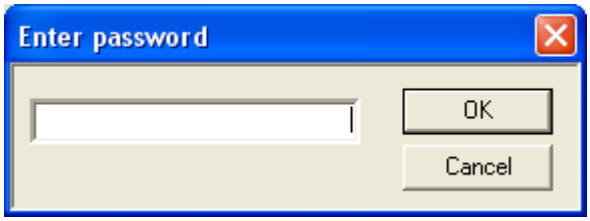


Figure 3.2.1 – Enter password

On entering the password *Current and voltage source manual control* window opens. The setup program window is open on its top (see Figure 3.2.2).

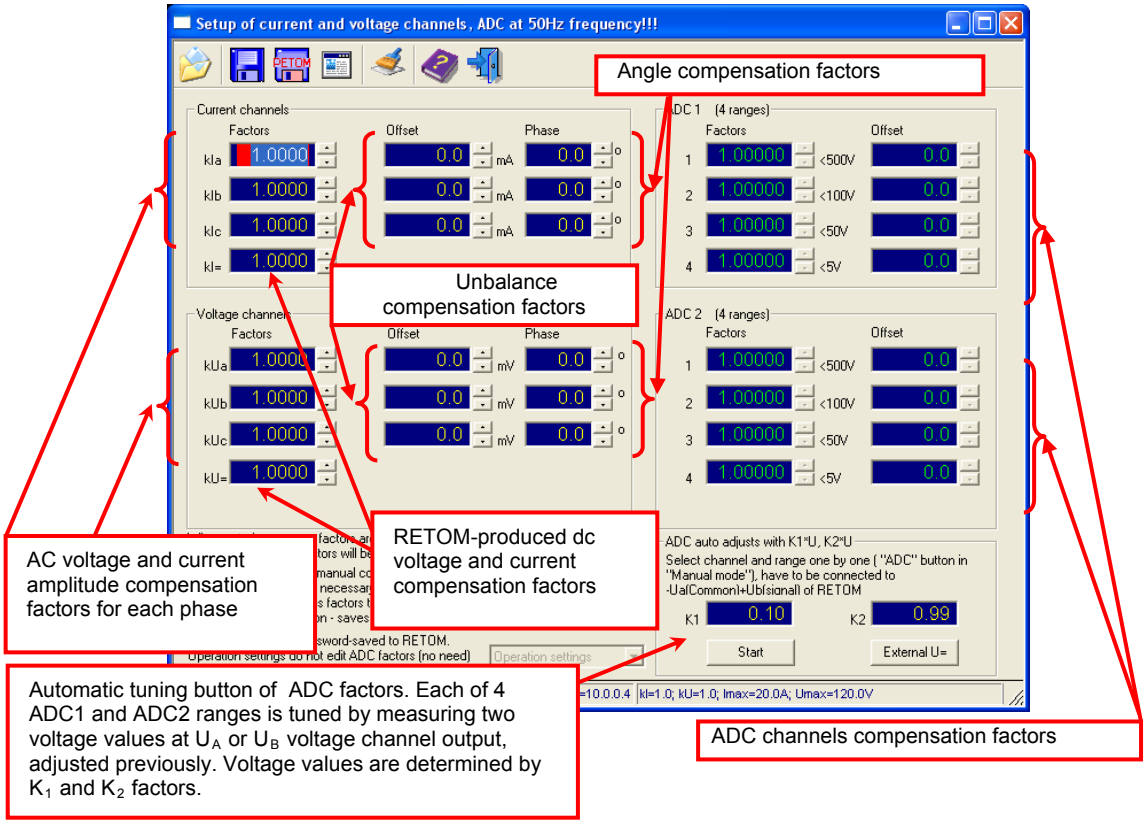

Setup of current and voltage channels, ADC at 50Hz frequency!!!
Angle compensation factors
Unbalance compensation factors
RETOM-produced dc voltage and current compensation factors
AC voltage and current amplitude compensation factors for each phase
Automatic tuning button of ADC factors. Each of 4 ADC1 and ADC2 ranges is tuned by measuring two voltage values at U_A or U_B voltage channel output, adjusted previously. Voltage values are determined by K1 and K2 factors.
ADC channels compensation factors
Current channels
Voltage channels
ADC 1 (4 ranges)
ADC 2 (4 ranges)
Factors
Offset
Phase
ADC auto adjusts with K1*U, K2*U
Start
External U=

Figure 3.2.2 – Channel Adjustment Program Window

3.2.3 How to Work with the Program

Offset compensation

Unit adjustment begins with offset compensation of amplifier outputs. Current channel offset (i.e. unbalance) is no more than ± 25 mA, and that for voltage channels is no more than ±30 mV. Each offset is monitored (reset to zero) by external **dc** milliammeter (for current channels) or **dc** millivoltmeter (for voltage channels). After connecting milliammeter (millivoltmeter) to current (voltage) channel and closing the red program switch in «Current and voltage source manual control» program window, the user tries to get minimum value on the measuring instrument by changing the editable field parameter (*Offset* fields) either manually or with ⇑ and ⇓ buttons next to the field. Factors for all current and voltage channels are set consequently in the same way.

Gain factor k_a (rms value) and angle offset $\Delta\varphi$ compensation for current and voltage channels

The Manufacturer tunes these factors under the following conditions:

- current sources - 0.625 Ω resistance load, factors for any channels are set at 10 A;
- voltage sources - 170 Ω resistance load, factors for any channels are set at 60 V.

To tune the required current channel gain factor connect the ammeter of class 0.2 or higher to its output terminal (e.g. I_a). Tuning can be carried out at different loads; checking is allowed at no load too. Thus, for basic (primary) tuning the resistor 0,625 Ω is used and the ammeter is connected between terminals I_a and I_n in series with load. If it is required to use RETOM-51 for checking relay with load impedance above 0.625 Ω, it is recommended to tune at actual load and to save it in archive for further use. Set the required current value in I_A field (e.g. 10 A). Switch on RETOM-51 by *Switch* toggle in “Current and voltage source manual control” window. Checking I_a current by ammeter change kI_a channel gain factor. The factor value can be changed by entering a new value by using the keyboard or buttons ⇑ and ⇓ located next to kI_a window. Voltage channel factors are tuned in the same way.

Angle tuning between current and voltage channel signals

Combinations of signal pairs when tuning angles:

$U_a – U_b$, $U_a – U_c$, $U_a – I_a$, $U_a – I_b$, $U_a – I_c$, here U_A phasor is taken as a basis, and angle compensations for other current and voltage phasors are set with reference to it. Actual angle under tuning is measured by a 0.5 class phase meter or visually on the oscilloscope display (in this case the current channel signal is taken from calibrated resistive shunt).

Example of tuning U_a / I_a angle:

- connect outputs to load and phase meter;
- set U_a = 100 V, 30°; I_a = 5 A, 10° in “Current and voltage source manual control” window;
- switch on RETOM-51;
- measure U_A/I_A angle with phase meter (e.g. 18°) and calculate the difference between set angle $\angle(U_A, I_A)$ (equal to 20°) and phase meter reading (18°);
- enter this difference (2°) into I_A channel phase field or change it with ⇑ или ⇓ buttons located next to it.

Phase meter readings should be equal to U_A/I_A set angle (20°).

Compensation (gain) factor tuning for voltage and current channels at DC current source mode

When current and voltage channels (U_{AB} and $=I_{ABC}$) are used in DC current and voltage source mode, specific factors are used for their compensation. Their fields (two editable fields) are located below those for main factors.

Factors are tuned as described above. DC external ammeter and voltmeter are used. DC current source mode is preselected for current and voltage channels in “Current and voltage source manual control” window. Recommendations on load and values to carry out compensation are:

- for current channels (“-“ I_N terminal, “+” I_{ABC} terminals): 0,625 Ω load, 10 A current value;
- for voltage channels (“-“ – U_A terminal, “+” – U_B terminal): 2.5 kΩ load, 150 V voltage value.

Tuning of ADC1 and ADC2 channel compensation factors (analog measuring inputs)

ADC channel (#1 or #2) and its measuring range are selected in “Current and voltage source manual control” window. Enter unequal values from 0.1 to 0.99 into *K1*U and K2*U ADC Auto adjusts with…* editable fields of “Setup of current and voltage channels, ADC…” window. ADC channel should be connected to U_A (or U_B)

terminal of RETOM-51 voltage channel with external cable. The program automatically outputs two voltage values from RETOM-51, ADC measures them and calculates the range deviation and the gain factor. Then it issues a *READY* message in about 5 s. Within this period it is recommended not to do anything with the program. Gain and deviation factors will be entered into fields of the ADC range channel being tuned. Then the next ADC channel range is tuned.

Tuned factors should be saved in a file with the help of toolbar buttons (see section “Archive Handling”). Saved factors are unique for each RETOM-51 and are used by all programs.

RETOM-51 has 2 tables of gain factor settings: factory and operating. The unit is delivered with equal tables (external PC can contain more adjustment files). On opening the CD file (or after factors have been edited) it is necessary to press “*Save factors to RETOM*” button ***with program switch in ON position*** to download the selected factors in RETOM (otherwise, factors will be recorded only to CD). Factory factors are downloaded into RETOM using password, while operating factors are user editable. Selected factors are read and displayed after program switch is ON or after one of the tables (factory or operating) is selected. When setup program is closed, all RETOM programs run with factors saved to the selected (one of two) table.

3.3 Current and Voltage Independent Source Manual Control

3.3.1 Application

The program permits to carry out independent manual or automatic control of three current and voltage sources, automatic recording of the tested protection operation and reset based on different criteria, to actuate protection logics via binary outputs, to measure and to make oscillographic testing of voltages connected to analog inputs (ADC).

3.3.2 Program Start

To start the program in the RETOM-51 main window the icon *Manual control* is used.

3.3.3 How to Work with the Program

Program design permits to control only one value at a time, which can be phase, linear or symmetrical component, phase offset angle or frequency. The program window is of the standard WINDOWS type (Figure 3.3.1).

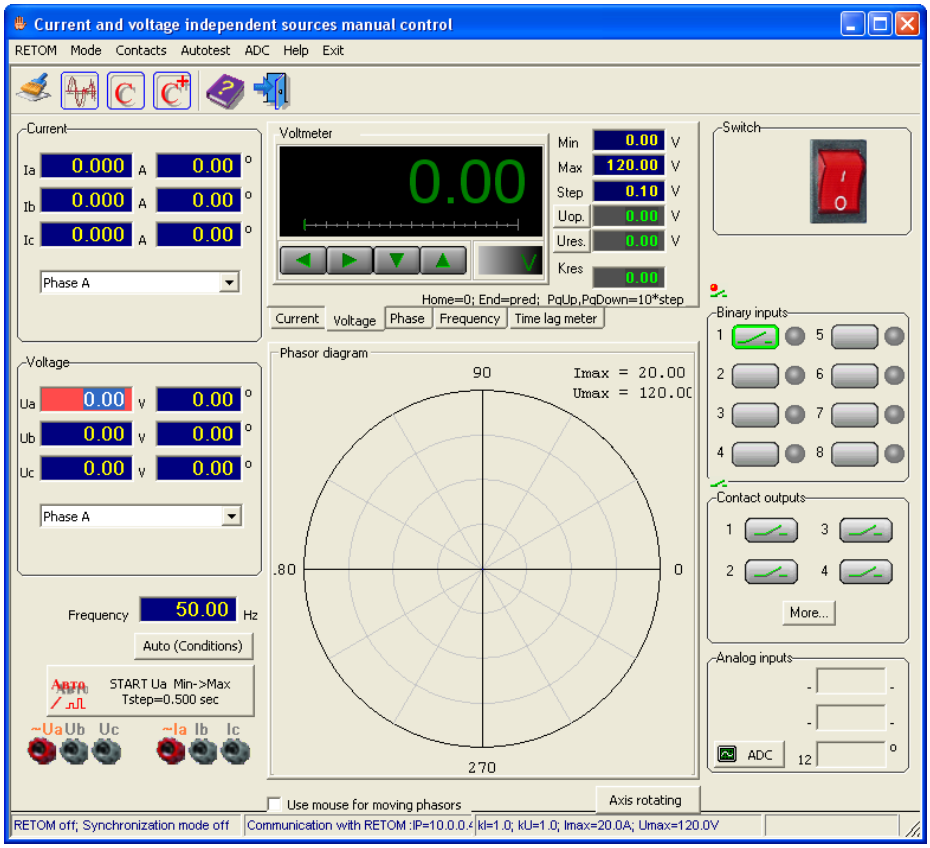


Figure 3.3.1 – *Current and voltage source manual control* program main window

In the upper part of the window, below the header, there is a menu including the following items:

- *RETOM* - is intended for RETOM-51 program switching ON/OFF (sub-items *On* and *Off*);

- *Mode* – sub-items: *I Phase components*, *I Symmetrical components*, *U Phase components*, *U Symmetrical components*. Current and voltage phase component modes permit to set corresponding phase values, and symmetrical component modes permit to set current and voltage direct, negative and zero sequence components with further program recalculation to phase values for RETOM-51 output. To some extend *Ammeter, Voltmeter, Phase meter* and *Time lag meter* sub-items duplicate switching carried out with the help of virtual instrument bookmarks located in the main program window in its upper central part. *Synchronization to mains* sub-item permits to switch On/Off current and voltage synchronization to mains frequency. This may be needed to synchronize currents and voltages generated by two or more RETOM-51, including remote ones (located at substations on different line ends);

- *Contacts* - duplicates four contact output control (sub-item *Contact outputs*) available in the "Output contacts" group of the main program window and eight binary inputs (sub-item *Binary inputs*) available in the "Input contacts" group of the main program window. Each output contact can be open or closed, and each binary input can be set to its normal state – normally open or normally closed;

- *Autotest* - is intended to open the dialogue window *Step time* in the automatic testing mode. Holding time at every step during automatic operation or reset search is set in its editable field. Search direction from min to max value Min→Max or vice versa - from max to min Max→Min - is also set here. Min and max values as well as the increment step are taken from corresponding virtual instrument fields located in upper central part of the main program window. Values (current, voltage, phase angle or frequency) that are currently active are only subject to changing. To start the automatic test press the *Start* button located in the lower left part of the main program window when the program switch is ON. Automatic frequency, phase, voltage and current change mode is introduced here to accelerate relay operation/reset characteristic search;

- *ADC* - is used to switch On/Off ADC channels #1 or #2 and to select their operating range (500 V, 100 V, 50 V and 5 V). Sub-item *Oscillograph* is used to display graphically the corresponding virtual instrument measured values;

- *Help* - activates *Help Service*;

- *Exit* - is used to exit the program.

Below the menu bar the *Toolbar* buttons are located:

- time lag meter activation;

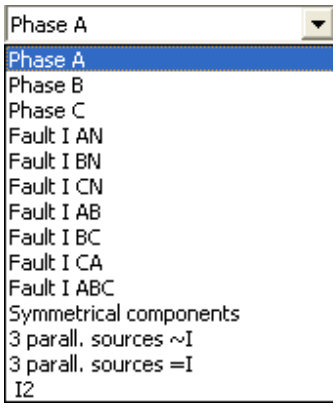
- zeroing of all values (current, voltage, angle);

- *Help Service* activation;

- exit the program.

To switch RETOM-51 On/Off use the program circuit breaker , located in upper right part of the program main window in *Switch* group.

The left part of the program main window is used to set output values. Editable fields for these values are combined in two groups *Current* and *Voltage.* The frequency setting field is located below. To set a reproducible value move the mouse cursor to the corresponding field, click the left mouse button and enter the due value. Drop-down lists to set the channel mode are located in the lower part of each group.



Current channel modes:

- *Phase A, Phase B, Phase C* – current supply via *AN, BN, and CB* channels. Switching to these modes is performed automatically when corresponding current or phase angle fields are activated by the mouse. Thus, control is independent (independent sources);

- *Fault I AN, Fault I BN, Fault I CN* – separate current supply via *AN, BN, or CN* channels (single-phase fault current simulation). Switching to one of these modes leads to zeroing and locking of inactive channels. Two new editable fields appear below (single-phase current and its phase angle) to control the selected channel;

- *Fault I AB, Fault I BC, Fault I CA,* - current supply via *AB, BC,* or *CA* channels (two-phase fault current AB, BC or CA simulation). Switching to one of these modes leads to zeroing and locking of inactive channel current output, and two new editable fields appear below (two-phase current and phase angle) to control the selected channels;

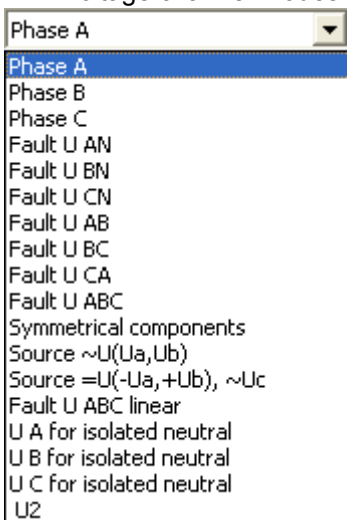
- *Fault I ABC* - current supply via *AN, BN* and *CN* channels (three-phase fault currents, ABC, simulation). Switching to this mode leads to zeroing of current outputs and two new editable fields (three-phase current and phase angle) appear below for corresponding control;

- *Symmetrical components* – supply of zero, direct and negative sequence current (I1, I2, I0) and their combinations;

- *3 parallel sources ~ I* – current supply via *AN, BN* and *CN* channel mode for triple output current (up to 60A). Output terminals of A, B, C current sources shall be connected in parallel. Switching to this mode activates two new editable fields (single-phase current and its phase angle) for corresponding control;

- *3 parallel sources =I* - DC current supply via *AN, BN* and *CN* channel mode. Output terminals of A, B, C current sources shall be connected in parallel. A, B, C joined terminals correspond to "+" potential, and N terminal corresponds to "–".

Voltage channel modes:



- *Phase A, Phase B, Phase C* – voltage supply via *AN, BN, and CB* channels. Switching to these modes is performed automatically when corresponding voltage or phase angle fields are activated by the mouse. Thus, control is independent (independent sources);

- *Fault U AN, Fault U BN, Fault U CN* – separate voltage supply via *AN, BN* or *CN* channels (single-phase fault voltage simulation). Switching to one of these modes causes zeroing of voltage output fields, locking of inactive voltage channels and setting them to idling voltage. Two new editable fields (single-phase voltage and phase angle) appear below. These fields are used for selected channel control. When active channel voltage exceeds idling voltage, further increment will be symmetrical over all three channels;

- *Fault U AB, Fault U BC, Fault U CA* - voltage supply via *AB, BC* or *CA* channels (AB, BC or CA two-phase fault voltage simulation). When switching to one of these modes inactive channel is set to idling voltage, and two new editable fields (phase-to-phase voltage and its phase angle) appear below to control the selected channels;

- *Fault U ABC* - voltage supply via *AN, BN* and *CN* channels (ABC three-phase fault voltage simulation). Switching to this mode leads to zeroing of output voltage fields, and two new editable fields (three-phase voltage and phase angle) appear below for corresponding control;

- *Symmetrical components* - supply of direct, negative and zero-sequence voltages (U1, U2, U0) and their combinations;

- *Source ~U(U_A,U_B)* – single-phase mode of supplying reverse phase voltages via channels *AN* and *BN for double increase of the output voltage* (up to 240 V). When switching to this mode two new editable fields will appear below (single-phase voltage and phase angle) for control via channels *A-B*. Editable fields of *CN* channel remain available for updating;

- *Source =U(-U_A,+U_B),~U_C* – at *AN* and *BN* channels - DC voltage supply, at *CN* channel - AC voltage supply. *A*-terminal has negative potential ("-"), *B*-terminal – positive potential ("+"). DC voltage is up to 339 V and AC voltage in CN channel – up to 120 V. This mode is intended for user-friendly operation with electronic relays that require auxiliary power supply and for reset time definition of auxiliary DC relays in *Time lag meter* mode. All RETOM-51 voltage channel outputs are equipped with relays that "disrupt" (disconnect) the tested relay winding when defining the reset time with DC voltage zeroing to exclude the tested relay shunting by internal voltage channel resistance. This causes opening of U_A and U_B channel internal relay contacts. When entering non-zero voltage into the Time lag meter *Min* field, U_A and U_B channel internal relays are not controlled and their contacts remain constantly closed.

- *Fault U ABC linear* – voltage supply via *AN, BN* and *CN* channels in √3 times less than the set voltage (three-phase fault voltage, ABC, simulation). Switching to this mode causes zeroing of output voltage channels and two new editable fields (*three-phase voltage* and *phase angle*) appear for corresponding control.

The main control element is located in central upper part of the main window – the multi-purpose virtual instrument combining time lag meter, voltage and current sources, phase angle and frequency controller functionality (see Figure 3.3.2).

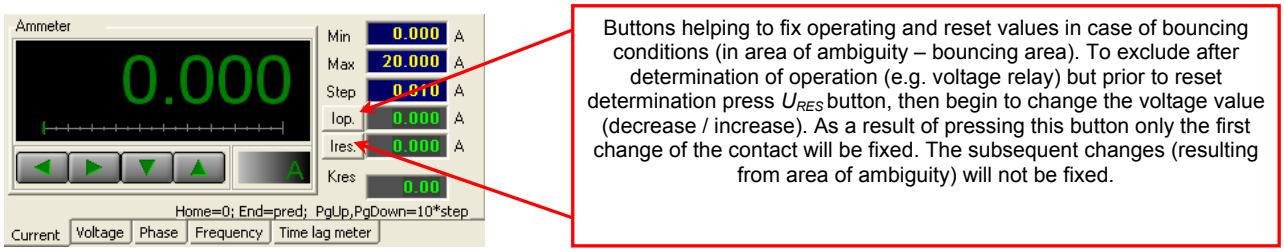

Ammeter
0.000
Min 0.000 A
Max 20.000 A
Step 0.010 A
Iop. 0.000 A
Ires. 0.000 A
Kres 0.00
Home=0; End=pred; PgUp,PgDown=10*step
Current
Voltage
Phase
Frequency
Time lag meter
Buttons helping to fix operating and reset values in case of bouncing conditions (in area of ambiguity – bouncing area). To exclude after determination of operation (e.g. voltage relay) but prior to reset determination press U_{RES} button, then begin to change the voltage value (decrease / increase). As a result of pressing this button only the first change of the contact will be fixed. The subsequent changes (resulting from area of ambiguity) will not be fixed.

Figure 3.3.2 – Multi-purpose virtual instrument

Instrument modes are switched by using tabs *Current, Voltage, Phase, Frequency and Time lag meter* located in its lower part, or by activating (e.g. with the mouse) current, voltage, phase angles or frequency fields in the left part of the program window. In *Time lag meter* mode this value corresponds to the field previously being active (current, voltage, phase angle or frequency) and the active contact state.

The right part of the virtual instrument contains fields conventionally divided into two groups - control and indication.

Control group includes:

- *Min* – minimum value setting;
- *Max* – maximum value setting;
- *Step* – value increment setting (no such field in *Time lag meter* mode, because its start causes a Min–Max (or vice versa) jump).

Indication group includes:

- Measured operating value (I_{OP}, U_{OP}, φ_{OP}, f_{OP}, t_{OP});
- Measured reset value (I_{RES}, U_{RES}, φ_{RES}, f_{RES}, t_{RES});
- K_{RES} – calculated reset factor (no such field in *Time lag meter* mode).

Operating, reset and reset factor fields are filled in when the selected (active) binary input connected to protection output terminals changes its state. In bouncing conditions use fixing buttons on the instrument (Figure 3.3.2 and comments to it).

Min and *Max* field designation. To avoid the tested equipment failure *Min* and *Max* characteristics have two different meanings – “general” is set from the toolbar, another - “local” - is set in the above-described fields. Min and Max local shall not exceed general values. Below the virtual instrument window there are four arrow buttons (no arrows in *Time lag meter* mode). Pressing or holding the buttons with the help of the mouse causes step increase/decrease. Pressing buttons causes increase/decrease of the delivered value.

These buttons are duplicated by keyboard cursor keys *↓/↑ and ←/→*.

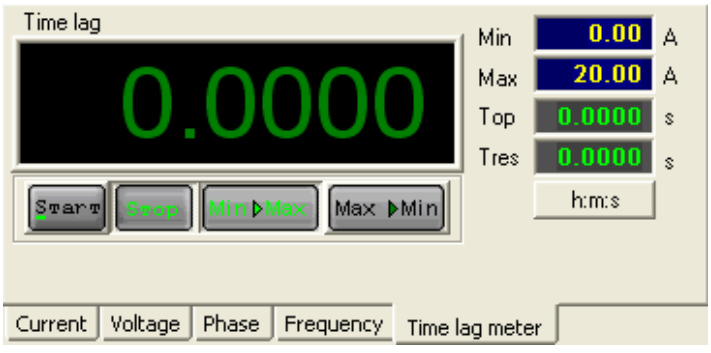


Figure 3.3.3 – Time lag meter (Seconds counter)

After Time lag meter is activated by the corresponding tab, buttons are replaced with <Start>, <Stop>, <Min→Max> and < Max→Min> (Figure 3.3.3) buttons that perform the following functions:

- <*Start*> – Time lag meter start;
- <*Stop*> – forced Time lag meter stop (if not from active contact);
- <*Min→Max*> – after pressing <Start> button transition from *Min* to *Max* value;
- <*Max→Min*> – reverse transition.

Operating and reset time values are entered into T_{OP}, T_{RES} fields.

Below the virtual instrument there is the phasor diagram field indicating current and voltage phasors generated by RETOM-51 (rms values). Counterclockwise angle direction is taken for positive. Phasor diagram diameter corresponds to the virtual instrument *Max* field. Setting the key "*Permit using mouse for moving phasors*" in the phasor diagram lower part, makes it possible to set and rotate phasors by clicking and holding the left mouse button. Press *Axis turn* button to turn the phasor diagram axis by 90° counterclockwise. The zero axis will become vertical. Press this button again to make the zero axis turn back to horizontal. Default *+R* axis is directed to the right.

Eight binary input fields are located to the right of the phasor diagram in *Binary inputs* group. Each field corresponding to a contact consists of two elements: contact button and indicating lamp. To select a contact as active (for operating or reset value recording) click the mouse on the contact button. The button and the contact inside will light green. Repeated click (clicks) on this button will inverse the contact state from normally open (NO) to normally closed (NC) and vice versa. When the device is started with the program circuit breaker, the indicator lamp will be green if active contact is open, and will be red in case it is closed.

Four output contact buttons are located in the *Contact outputs* group below binary input fields. These buttons are intended to switch RETOM-51 output relays ON or OFF. The relay state is represented by a schematic contact symbol inside each button.

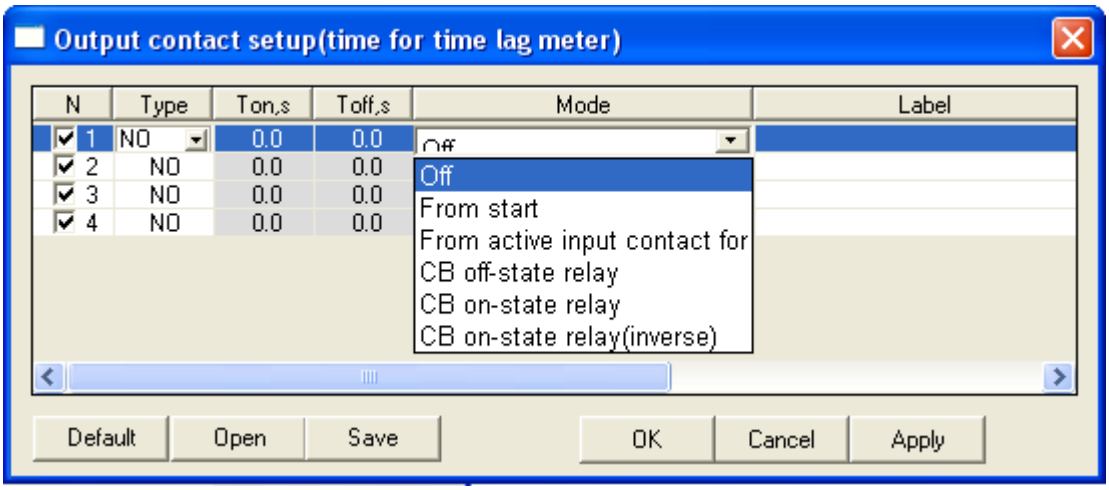


Figure 3.3.4 – Output contacts setting window

Protection logic is actuated by opening or closing RETOM-51 output contacts. Output contacts setting is enabled only in *Time lag meter* mode after clicking the <*More…*> button located below the buttons with contact symbols. The *Output contact setup* window opens (see figure 3.3.4) and prompts to set the contact normal state, Off and On time, and the operating modes for each of four outputs:

- *Off* - operation logic is not determined, and output contact state corresponds to its position in the *Contact outputs* group. Fields T_{ON} and T_{OFF} are not available for editing;
- *From start* – output relay contact changes its state to the opposite in *Ton* time and resets in T_{OFF} time relative to <*Start*> button of *Time lag meter* press;
- *From active input contact for* - binary output relay contact changes its state to the opposite in T_{ON} time and returns to its original state in T_{OFF}, relative to active input contact switching;
- *CB off-state relay* - output relay contact closes on active input contact (binary input) operation; simulation of close circuit supervision logic (NO);
- *CB on-state relay* - output relay contact remains close until active input contact (binary input) operates; it opens on operation (NC);
- *CB on-state relay (inverse)* - if type NO is selected, output relay contact will close on binary input 2 closing; if type NC is selected, output relay contact will open on binary input 2 closing.

Output relay operation logic has higher priority to settings specified in the *Output contacts* group of the main program window in *Time lag meter* mode.

The *Analog inputs* group with <*ADC*> button and *U1* and *U2* fields located below output contact fields displays rms values of voltages connected to RETOM-51 analog inputs. When ADC is off *U1* and *U2* fields are inactive.

Measuring inputs are enabled by pressing <*ADC*> button or by selecting the corresponding menu item, the *ADC mode* dialog box opens (Figure 3.3.5).

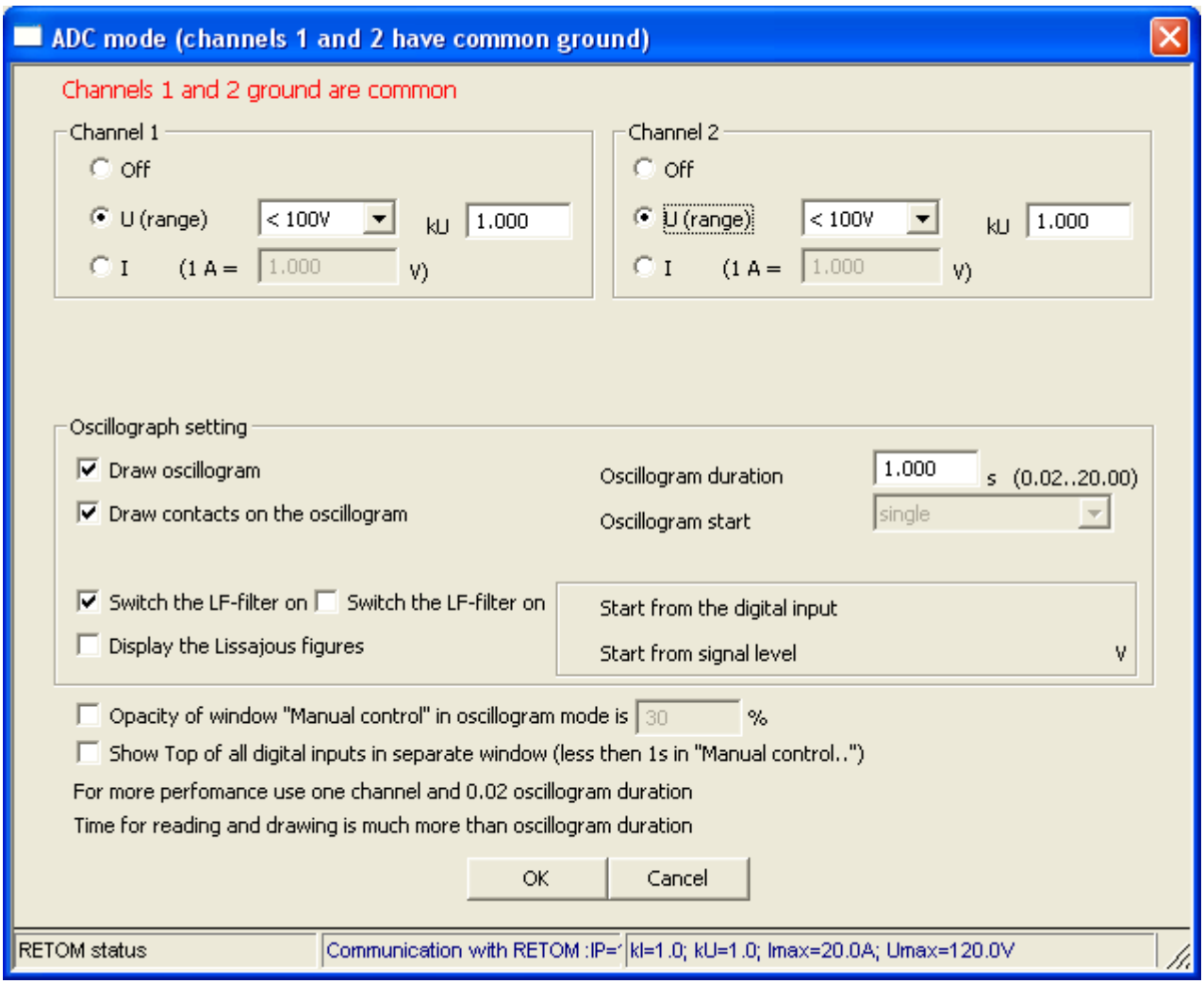


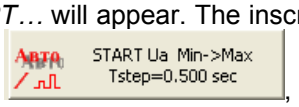
Figure 3.3.5 – ADC *Mode* dialog box

Then it is possible to switch *ADC* channels on or off, select required input voltage range or set current measuring mode (clamp-on ammeter is required) by entering ampere/volt proportion constant into the corresponding editable field. Disturbance recording mode starts by checking *Draw Oscillogram* field or by selecting *Oscillograph* sub-item in *ADC* menu. After that the disturbance recorder dialogue appears on top of the program main window.

Oscillogram duration field sets the disturbance recording (together with measuring) duration time, and *Redraw time T* field sets the signal redraw interval (either in oscillogram (if active) or in *U1* or *U2* measured values fields).

Besides, synchronization mode is provided for every ADC channel on positive or negative zero transition (i.e. the sinusoidal always starts from 0). Different oscillograph *Start mode*s are provided as well: *After time T* - oscillograms are redrawn after the set time interval; *Redraw time T* - oscillograms are redrawn after max possible time due to computer efficiency and communication port rate; *Single* - oscillogram is drawn only once. When the program circuit-breaker is On, two additional Start modes are displayed: *Start from the digital input* - start is performed on change of the selected binary input state; *Start from signal level* - start is performed on exceeding the set voltage level.

To accelerate the time of oscillogram drawing it is desirable to enter the min. time of *Oscillogram duration* and not to load the binary input buffer. The LF filter removes HF components. To draw the Lissajous pattern select both ADC channels, there are input fields kUadd for signal level change. Available ADC settings are changed depending on the actual operating mode – e.g., when working with the time lag meter the ADC mode is automatically set to “single-shot start” synchronized with the time lag meter start.

For testing in semiautomatic mode when the program circuit-breaker is On two buttons *Auto (Conditions)* and *Auto START…* will appear. The inscription of the *Auto START…* button changes according to active current or voltage field 

, as well as according to the conditions specified in the Automatic test conditions window (Figure 3.3.6) - press the button *Auto (Conditions)* to open it.

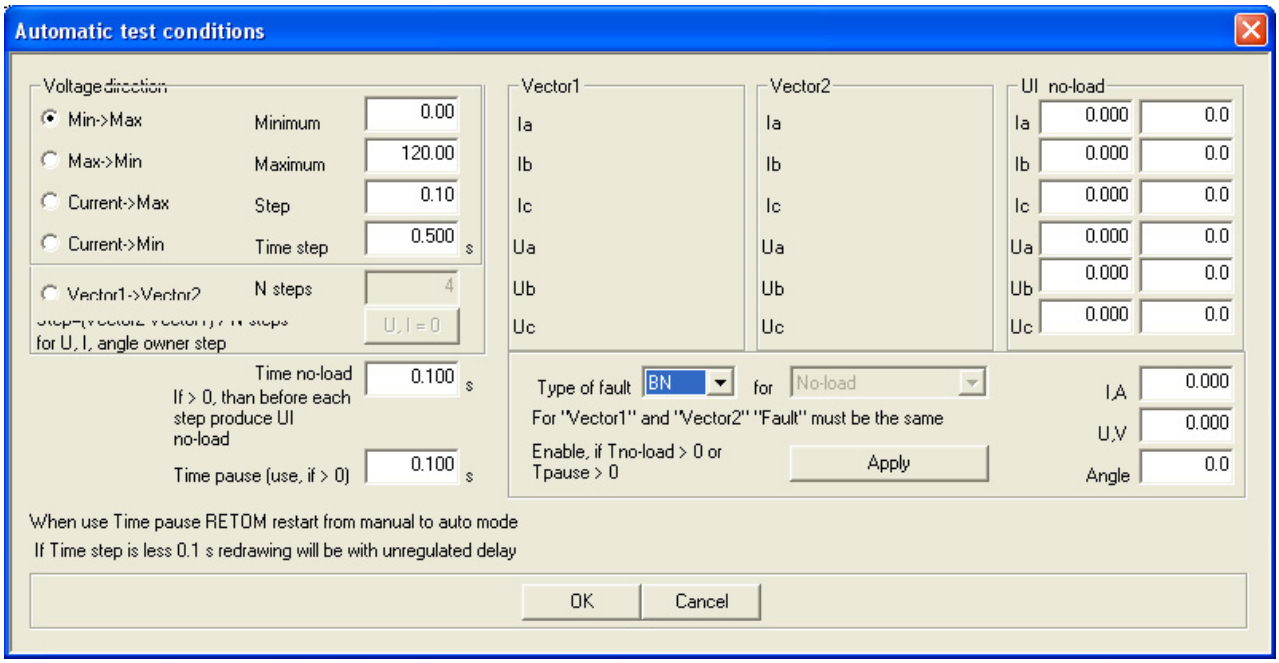


Figure 3.3.6 – *Automatic test conditions* dialog box

Search directions, minimum, step, maximum of the active field value (red highlighted in the “Manual control…” window) are specified in the *Automatic test conditions* dialog box. It can be current, voltage, angle or frequency. The parameters in this dialog box depend on the active field in the “Manual control…” window. Step time is also specified here. If pause time has been entered the action will be applied stepwise but not smoothly. When applying action only current, voltage or angle active field value changes. Other parameters remain unchangeable. But in the *Vector 1-> Vector 2* mode any currents and voltages can be specified. In this mode *Minimum, Step* and *Maximum* are not available but *Number of steps (N steps)* is enabled. Each value gets its step equal to the *(Vector 1-> Vector 2) / N steps* expression.

3.4 Automatic Current Relay Test

3.4.1 Application

The program is intended for automatic testing of current relay and multistage current protection including directional.

The program allows to take readings of the following parameters in the automatic mode:

1) operating and reset current, relay reset ratio or current protection zones;
2) relay operating and reset time or operating and reset current protection zones time;
3) percentage deviation from the setting;
4) relay time-current characteristic or multizone current protection characteristic.

3.4.2 Program Start

To start the program in the RETOM-51 main window the icon *Current relay* is used.

The program operating window is shown in Figure 3.4.1.

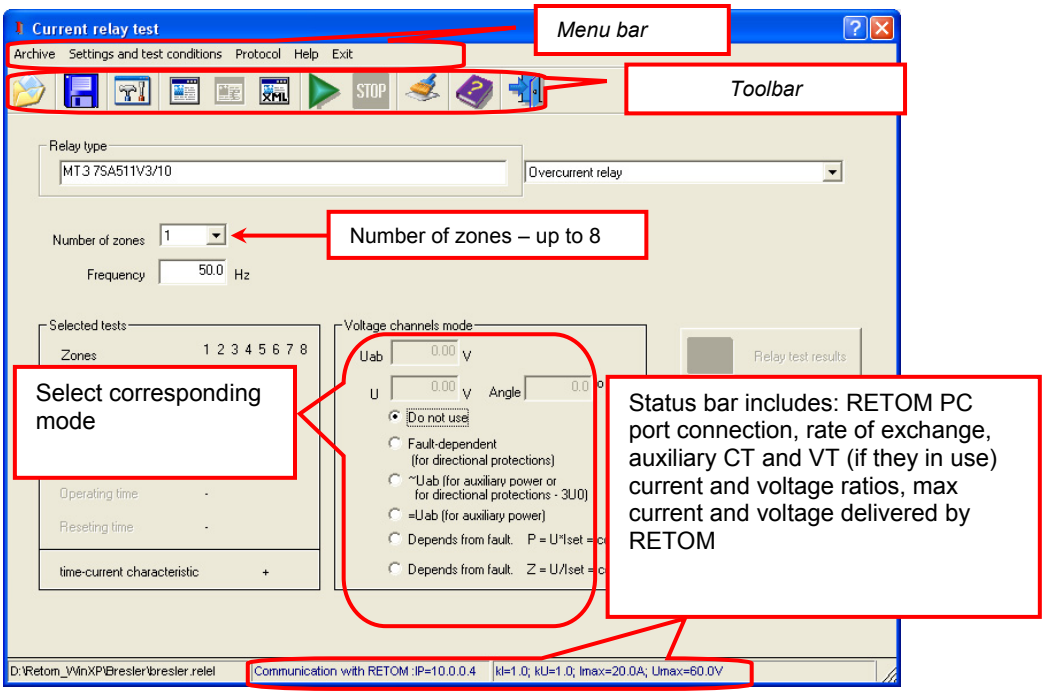

Current relay test
Archive Settings and test conditions Protocol Help Exit
Menu bar
Toolbar
Relay type
MT3 7SA511V3/10
Overcurrent relay
Number of zones
1
Number of zones – up to 8
Frequency
50.0 Hz
Selected tests
Zones 1 2 3 4 5 6 7 8
Voltage channels mode
Uab 0.00 V
U 0.00 V Angle 0.0
Do not use
Fault-dependent (for directional protections)
~Uab (for auxiliary power or for directional protections - 3U0)
=Uab (for auxiliary power)
Depends from fault. P = U*Iset = c
Depends from fault. Z = U/Iset = c
Relay test results
Operating time -
Reseting time -
time-current characteristic +
Select corresponding mode
Status bar includes: RETOM PC port connection, rate of exchange, auxiliary CT and VT (if they in use) current and voltage ratios, max current and voltage delivered by RETOM
D:\Retom_WinXP\Bresler\bresler.relel
Communication with RETOM :IP=10.0.0.4
ki=1.0; kU=1.0; Imax=20.0A; Umax=60.0V

Figure 3.4.1 – *Automatic Current relay test* program operating window

Program *Menu* items are duplicated by *Toolbar* buttons (Figure 3.4.2).

Figure 3.4.2 – *Toolbar* buttons

Menu items and *Toolbar* buttons functions:

Archive (*buttons)* – call of archive window offering to open and save an archive file (see section «Archive Handling»).

Settings and test conditions (*button)* – call of parameter settings and test conditions window.

Protocol (*buttons)* – view of tests protocol with availability to print out.

Start, *Stop* buttons – enable test start and stop/pause.

Protocol clearing button – sets Protocol data to zero.

Help button – opens *Help*.

Exit button – closes the program

3.4.3 How to Work with the Program

The program is operated in the following way. Relay/protection type is typed into indicated field, the number (up to 8) of stages is selected, i.e. either multi-step protection or up to 8 current relays connected in series are tested. In case the protection is directional, e.g. residual overcurrent protection, and AC voltage simulating zero-sequence voltage $3U_0$ is needed, it is necessary to select $\sim U_{AB}$ mode in the *Voltage Channels Mode* (Figure 3.4.3) and set this voltage value and the angle between voltage and current.

When current protection testing comprising current relay, time relay and interposing relays, requiring DC voltage for interposing relays and time relay supply (or for microelectronic or microprocessor relay supply) it is necessary to select $=U_{AB}$ mode and set this DC voltage value.

When testing current protection where all phase voltage values are used, it is necessary to select *Fault-dependent* mode and set voltage for the faulted phase as well as voltage-current angle. The test delivers voltage star. Voltages of the healthy phases (or a phase for two-phase faults) are equal to 57.73 V.

When testing simple relays (no voltage circuits) it is necessary to use "*Do not use"* mode.

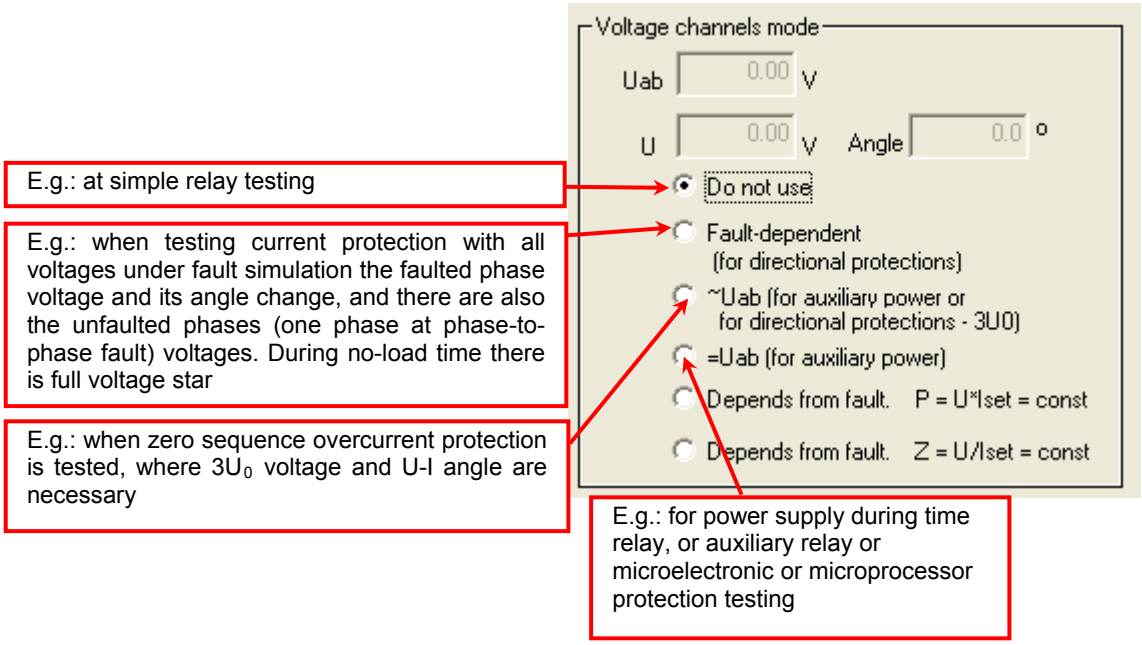

Voltage channels mode
Uab
0.00
V
U
0.00
V
Angle
0.0
o
Do not use
Fault-dependent
(for directional protections)
~Uab (for auxiliary power or
for directional protections - 3U0)
=Uab (for auxiliary power)
Depends from fault. P = U*Iset = const
Depends from fault. Z = U/Iset = const
E.g.: at simple relay testing
E.g.: when testing current protection with all voltages under fault simulation the faulted phase voltage and its angle change, and there are also the unfaulted phases (one phase at phase-to-phase fault) voltages. During no-load time there is full voltage star
E.g.: when zero sequence overcurrent protection is tested, where 3U0 voltage and U-I angle are necessary
E.g.: for power supply during time relay, or auxiliary relay or microelectronic or microprocessor protection testing

Figure 3.4.3 – Test modes

Then it is necessary to specify settings and test conditions, to set required options. Thus *Archive* file (or a new one) is created where all test parameters are saved. After setting all parameters press <*Start*> button. If necessary, a test can be stopped by <*Stop*> button. After the test it is required to save the protocol to *Archive* using <*Save as*> button.

The *Settings and test conditions* window appears by pressing button of the *Toolbar.*

The *Settings and test conditions* window is shown in Figure 3.4.4.

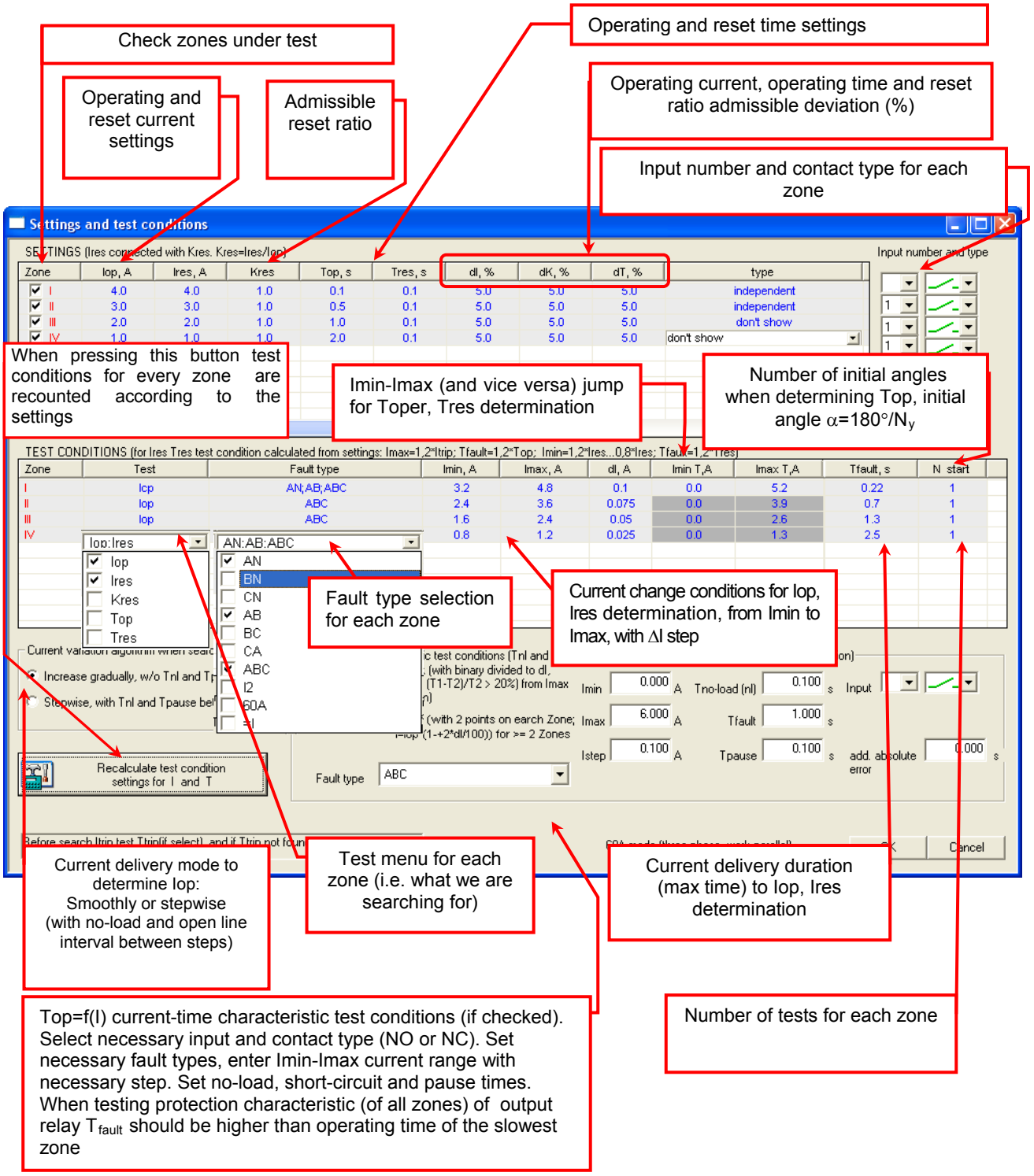

Check zones under test
Operating and reset current settings
Admissible reset ratio
Operating and reset time settings
Operating current, operating time and reset ratio admissible deviation (%)
Input number and contact type for each zone
Settings and test conditions
When pressing this button test conditions for every zone are recounted according to the settings
Imin-Imax (and vice versa) jump for Toper, Tres determination
Number of initial angles when determining Top, initial angle α=180°/Ny
Fault type selection for each zone
Current change conditions for Iop, Ires determination, from Imin to Imax, with ΔI step
Recalculate test condition settings for I and T
Current delivery mode to determine Iop: Smoothly or stepwise (with no-load and open line interval between steps)
Test menu for each zone (i.e. what we are searching for)
Current delivery duration (max time) to Iop, Ires determination
Top=f(I) current-time characteristic test conditions (if checked). Select necessary input and contact type (NO or NC). Set necessary fault types, enter Imin-Imax current range with necessary step. Set no-load, short-circuit and pause times. When testing protection characteristic (of all zones) of output relay Tfault should be higher than operating time of the slowest zone
Number of tests for each zone

Figure 3.4.4 – *Settings and test conditions* Window

3.4.4 Test Protocol

According to test results the *Protocol* is completed which can be shown on the screen through the *Menu* or after pressing the *Toolbar* button.

All necessary parameters are registered in the protocol, i.e. protection, options, settings, test conditions and results, etc. (Figure 3.4.5).

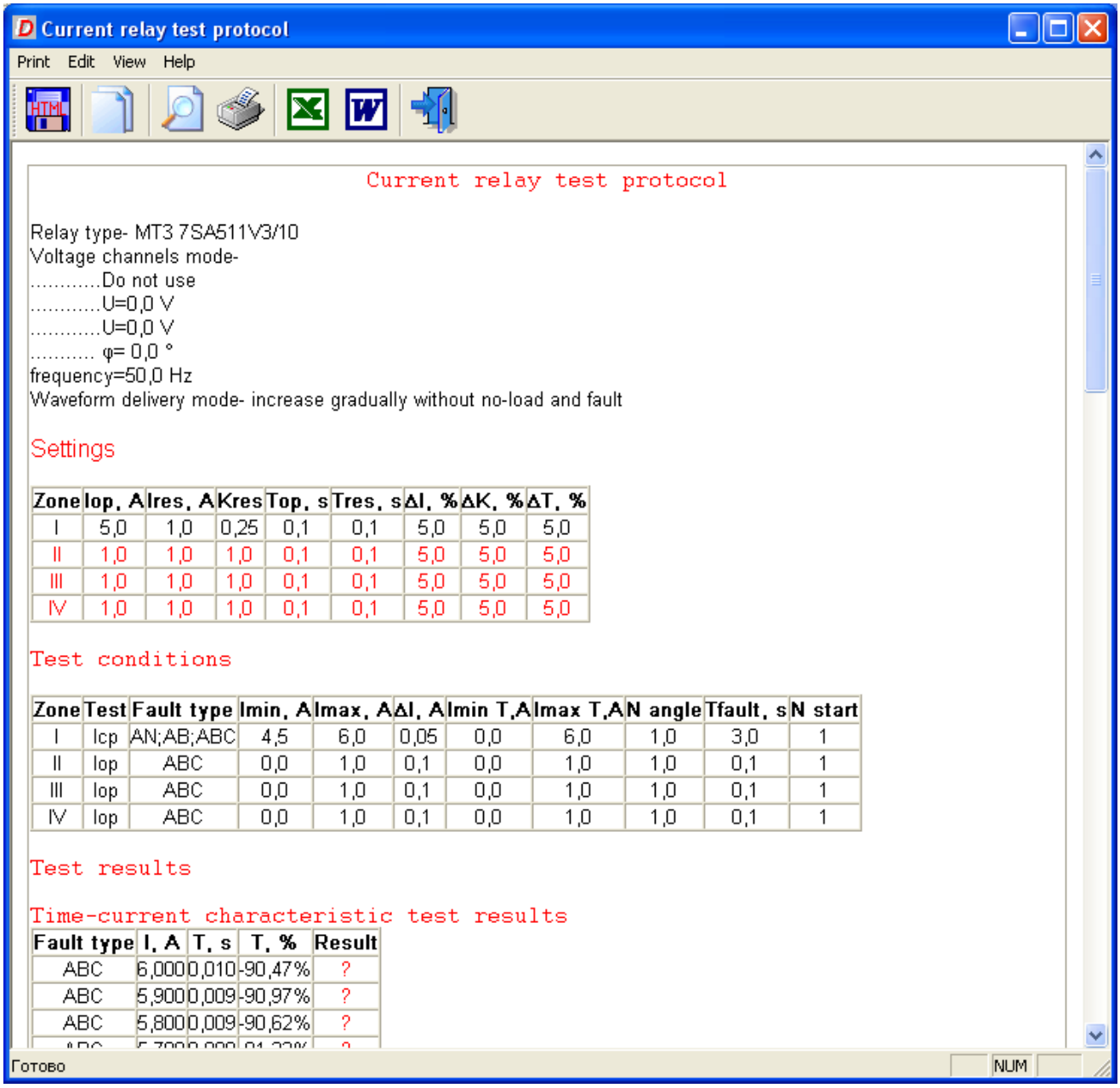

Current relay test protocol
Print Edit View Help
Current relay test protocol
Relay type- MT3 7SA511V3/10
Voltage channels mode-
.....Do not use
.....U=0,0 V
.....U=0,0 V
..... φ= 0,0 °
frequency=50,0 Hz
Waveform delivery mode- increase gradually without no-load and fault
Settings
Zone Iop, A Ires, A Kres Top, s Tres, s ΔI, % ΔK, % ΔT, %
I 5,0 1,0 0,25 0,1 0,1 5,0 5,0 5,0
II 1,0 1,0 1,0 0,1 0,1 5,0 5,0 5,0
III 1,0 1,0 1,0 0,1 0,1 5,0 5,0 5,0
IV 1,0 1,0 1,0 0,1 0,1 5,0 5,0 5,0
Test conditions
Zone Test Fault type Imin, A Imax, A ΔI, A Imin T,A Imax T,A N angle Tfault, s N start
I Icp AN;AB;ABC 4,5 6,0 0,05 0,0 6,0 1,0 3,0 1
II Iop ABC 0,0 1,0 0,1 0,0 1,0 1,0 0,1 1
III Iop ABC 0,0 1,0 0,1 0,0 1,0 1,0 0,1 1
IV Iop ABC 0,0 1,0 0,1 0,0 1,0 1,0 0,1 1
Test results
Time-current characteristic test results
Fault type I, A T, s T, % Result
ABC 6,000 0,010 -90,47% ?
ABC 5,900 0,009 -90,97% ?
ABC 5,800 0,009 -90,62% ?
Готово
NUM

Figure 3.4.5 – *Protocol* Window

3.5 Automatic Voltage Relay Test

3.5.1 Application

The program is designed for voltage relay automatic test. It allows to carry out a multiple test under one set of conditions and modes.

The program permits:

- To test relay technical data:
  1) Determine operate and reset voltage;
  2) Determine operate and reset time;
  3) Compute reset ratio;
  4) Compute percentage of deviation from setting;
- To carry out printable test protocol;
- To log all protocol and test data to archive.

3.5.2 Program Start

To start the program the *Voltage Relay* icon ( ) in RETOM-51 program main window is used.

3.5.3 How to Work with the Program

Voltage relay automatic test program window is shown in Figure 3.5.1.

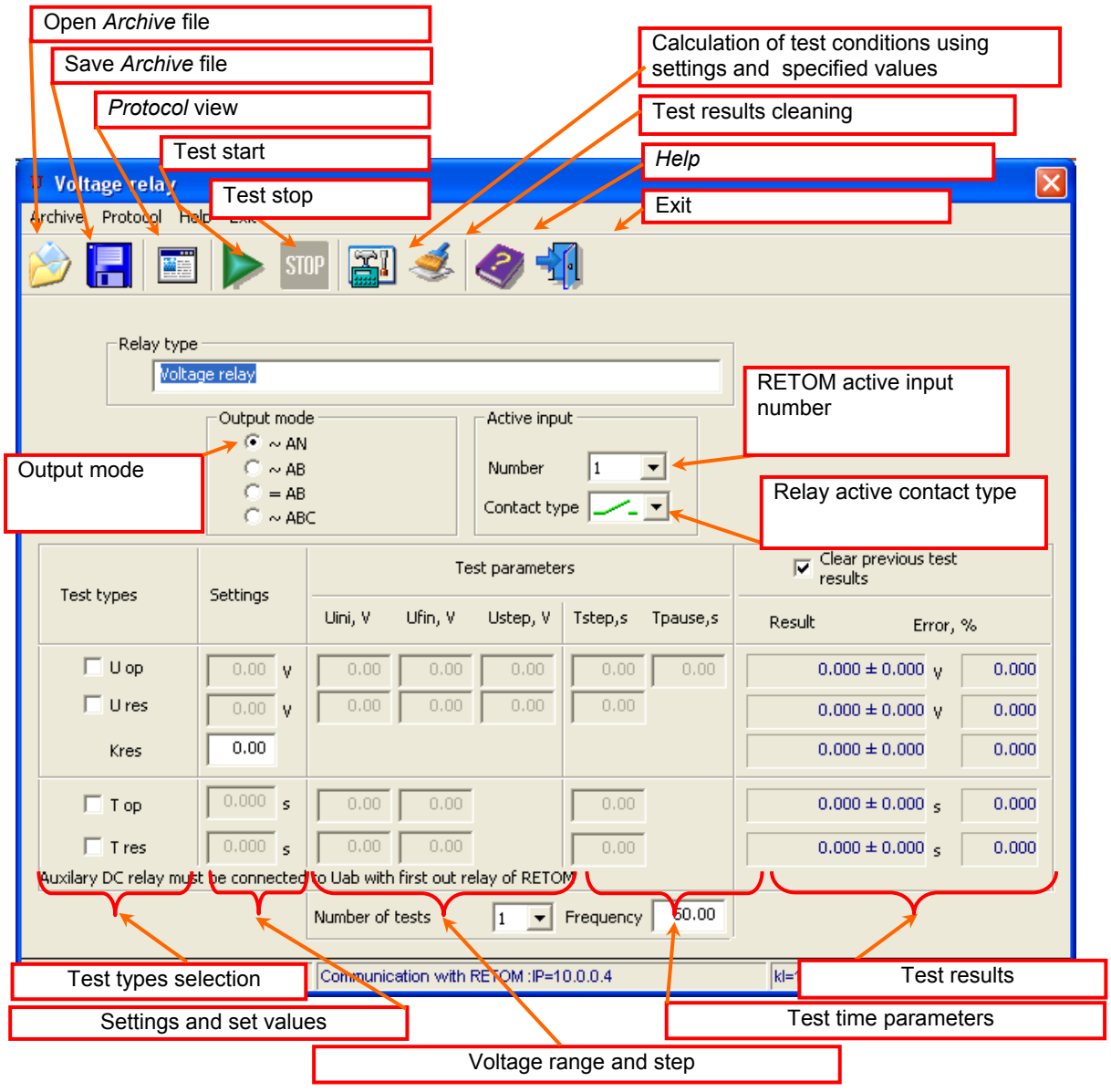


Figure 3.5.1 – *Automatic Voltage Relay Test* program window

To test the relay it is required to:

- connect relay operating winding to RETOM-51 voltage channels;
- connect relay contact to RETOM-51 binary input;
- select tested parameters;
- enter relay settings;
- enter test voltage range and variable step;
- enter test time data;
- select number of tests;
- switch-on RETOM-51 and start testing.

Depending on operating relay type and voltage range the relay is connected to following RETOM-51 voltage channels:

- up to ~120 V - to *AN* channel;
- up to ~240 V - to *AB* channels, U_A and U_B voltages are in phase opposition;
- up to =339 V - to AB channels («-» at U_A terminal, «+» at U_B terminal).

Corresponding item is selected in the program window in *Connection diagram* control group.

The relay contact is connected to RETOM-51 binary input. RETOM-51 input number (1 – 8) and relay contact type (NO or NC) are selected in the program window.

3.5.4 Operation Algorithm

The relay operating and reset voltage are searched by the smooth voltage variation within the set range U_{INI} – U_{FIN} with a step U_{STEP}. At each step contact operation over T_{STEP} time is expected. The actual operating voltage value is recorded when the relay output switches.

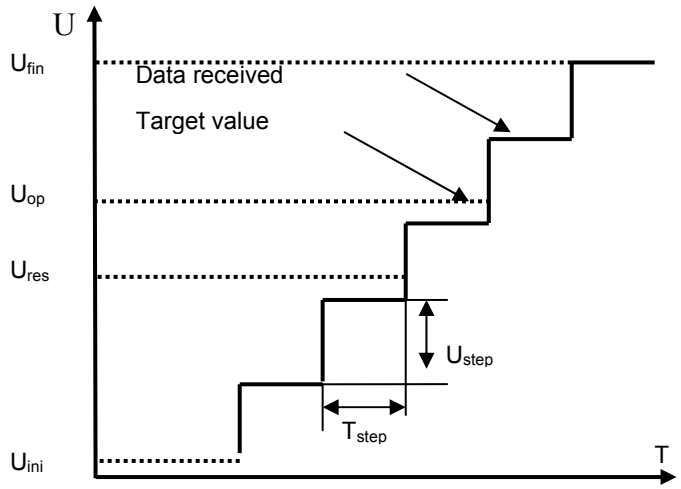


Figure 4.5.2 – U_{OP} and U_{RES} determination chart by smooth voltage variation (without pauses)

Another way to supply voltage is Shot determination mode. For example, when testing electronic DC relay РП-18 with long reset time (about 2 s), the voltage shall be supplied stepwise at each step to search U_{op}. In this case the test with a pause between voltage supply is used and the required value shall be entered into the T_{PAUSE} field (Figure 3.5.3).

The accuracy of U_{OP} and U_{RES} is determined by U_{STEP} value.

T_{STEP} should be selected by 1.2 – 1.5 times higher than the relay operating time setting.

To obtain T_{OP}, T_{RES} stepwise the voltage is changed within the U_{ini} to U_{fin} range and maintained within T_{STEP} time.

When it is required to determine spread in parameters the number of tests can be increased (typical number – 3 – 5 tests).

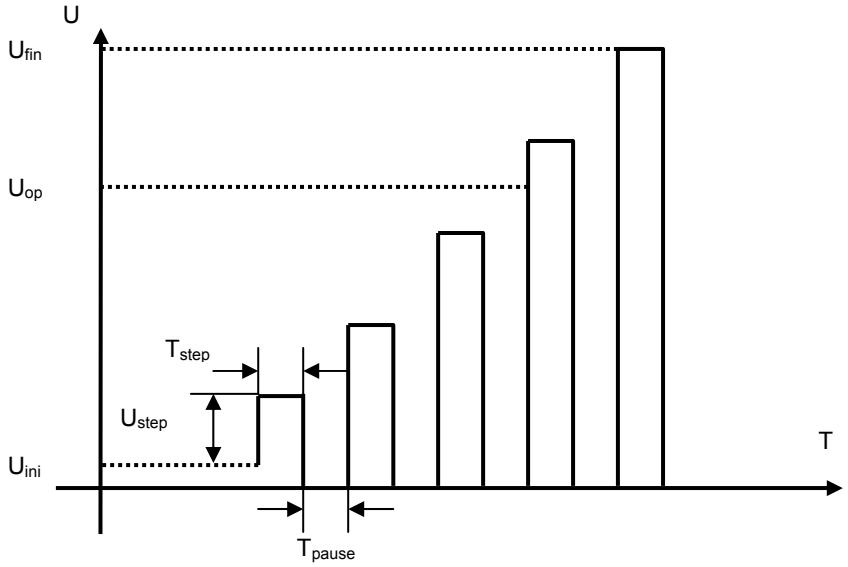


Figure 3.5.3 – U_{OP} determination chart with T_{PAUSE}

Test results are compared with setting values and a relative error is calculated by the formula $\Delta = (R-S)/S*100\%$, where Δ - error, R – result data, S – setting.

The protocol presents test results as average measured parameter and max error (Figure 3.5.4).

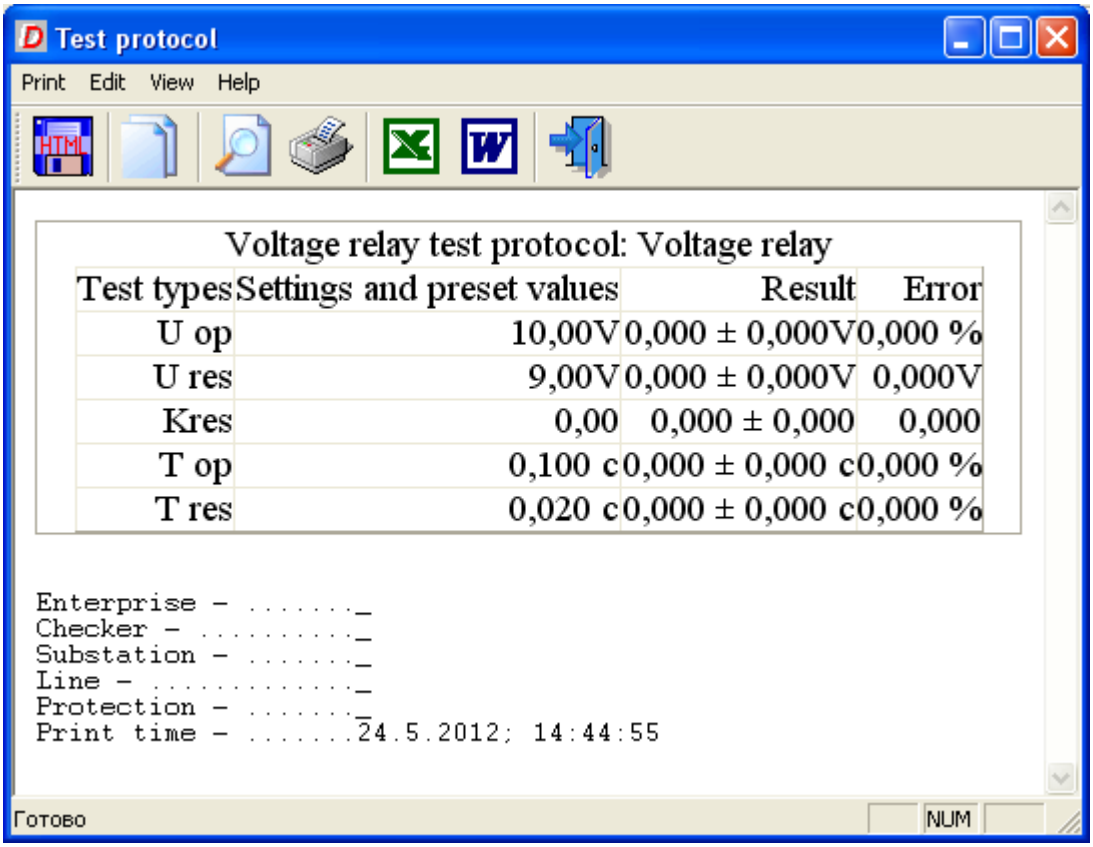

Test protocol
Print Edit View Help
Voltage relay test protocol: Voltage relay
Test types Settings and preset values Result Error
U op 10,00V 0,000 ± 0,000V 0,000 %
U res 9,00V 0,000 ± 0,000V 0,000V
Kres 0,00 0,000 ± 0,000 0,000
T op 0,100 c 0,000 ± 0,000 c 0,000 %
T res 0,020 c 0,000 ± 0,000 c 0,000 %
Enterprise – .....
Checker – .....
Substation – .....
Line – .....
Protection – .....
Print time – 24.5.2012; 14:44:55
Готово
NUM

Figure 3.5.4 – Voltage relay test protocol

Protocol description is given in the "*Automatic Current relay test"* program part.

3.6 Automatic Power Direction Relay Test

3.6.1 Application

The program is intended for automatic power direction relay test. It allows to carry out a multiple test under one set of conditions and modes.

The program allows to:

- test the relay technical data:
  1) No operation without current;
  2) No operation without voltage;
  3) relay characteristic angle φ_{CHAR}, relay operating angle range;
  4) operation and reset voltage values, operation power and reset ratio;
  5) operation and reset current values, current reset ratio;
  6) operation and reset time;
  7) no operation at reverse power (S_{REV}) shedding;
  8) reorientation time;
  9) no contact vibration;
- carry out printable test protocol.
- log all protocols and test data to archive.

3.6.2 Program Start

To start the program the *Power Relay* icon ( ) in RETOM-51 program main window is used.

3.6.3 How to Work with the Program

The *Automatic Power Direction Relay Test* program window is shown in Figure 3.6.1.

To test the relay it is required to::

- connect relay operating windings to RETOM-51 current and voltage channels;
- connect relay contact to RETOM-51 binary input;
- select necessary tests;
- enter relay settings;
- enter necessary main and auxiliary tests conditions;
- enter test time data;
- switch on RETOM-51 and start the tests.

According to the relay type (presence or absence of supply voltage) operating and supply voltages of the relay are connected to the following RETOM-51 voltage channels with the following ranges:

- no-supply: operating voltage is connected to U_C and U_N channels, the range is up to ~120 V;

- ac voltage supply: operating voltage is connected to U_C channel (U_C and U_N terminals), range is up to ~120 V, supply voltage is fed from U_A и U_B channels, range is up to ~240 V, voltages U_a and U_b are set in phase opposition;

- dc voltage supply: operating voltage is connected to U_C channel (U_C and U_N terminals), range is up to ~120 V, supply voltage is fed from U_A and U_B channels, range is up to =339 V, where the channel (phase) U_A has “-” and the channel (phase) U_B has “+”.

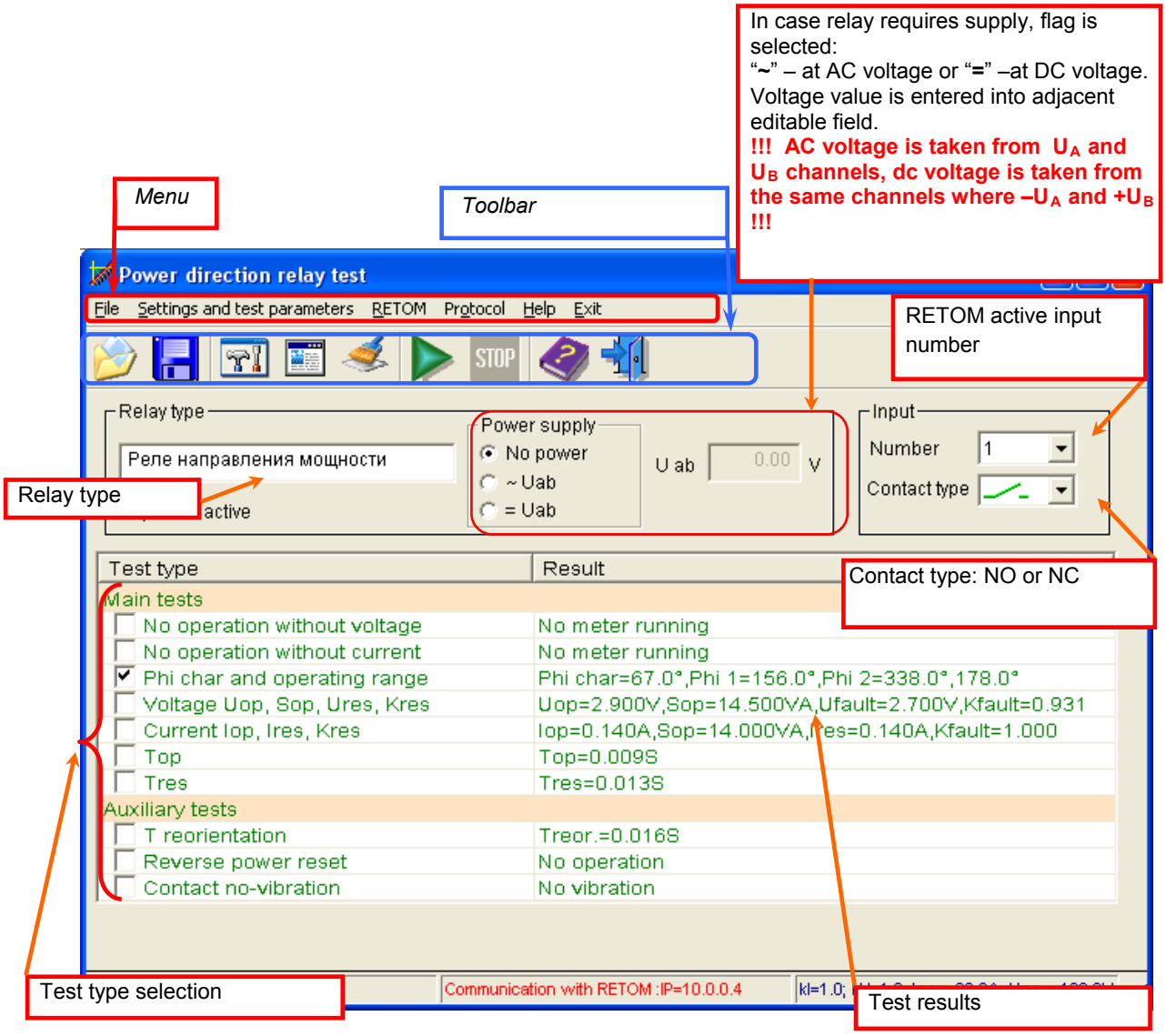


Figure 3.6.1 – *Automatic Power Direction Relay Test* program window

3.6.4 Settings and Test Parameters Window

This window is displayed by selecting *Settings and test parameters* menu item or by pressing *Settings and test parameters* toolbar button (see figure below).

The window is intended to specify settings and test parameters (Figures 3.6.2 – 3.6.4).

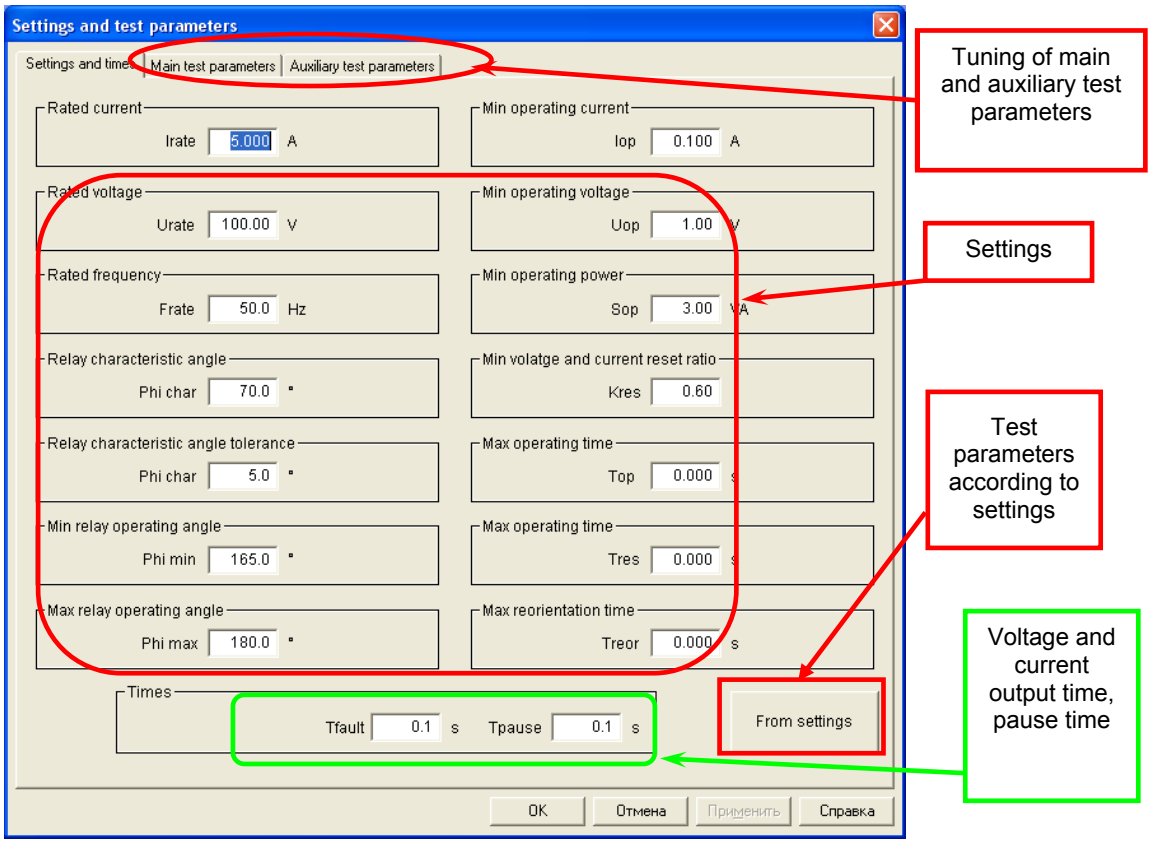


Figure 3.6.2 – Settings and test parameters window. *Settings and time* tab

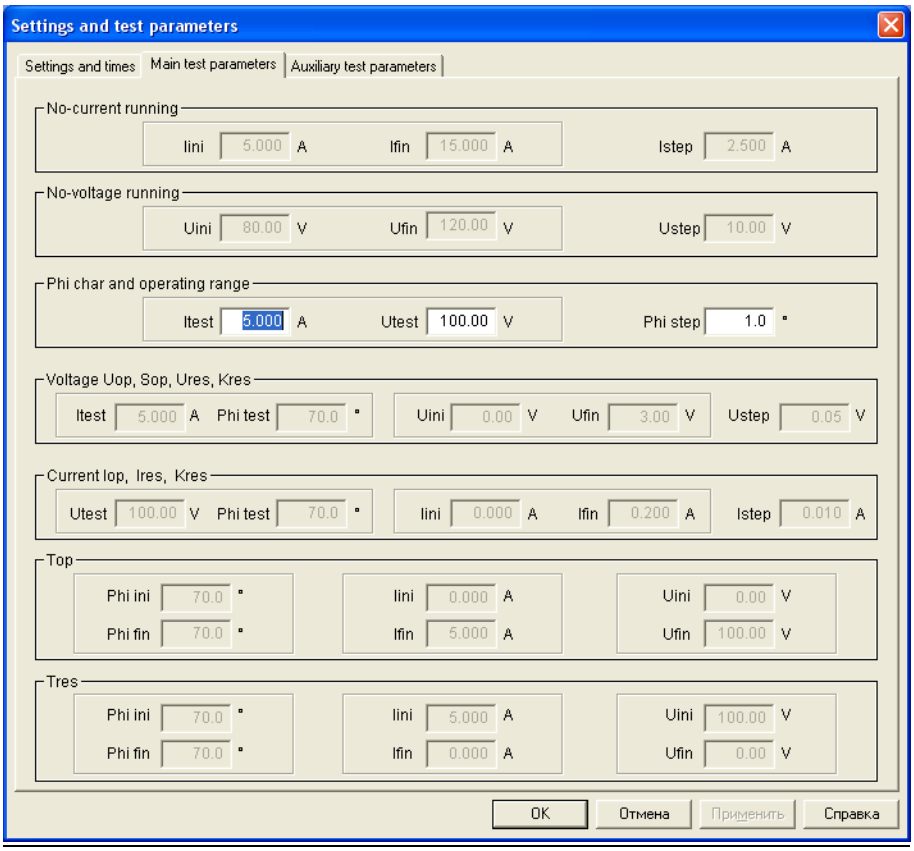


Figure 3.6.3 – Settings and test parameters window. *Main test parameters* tab

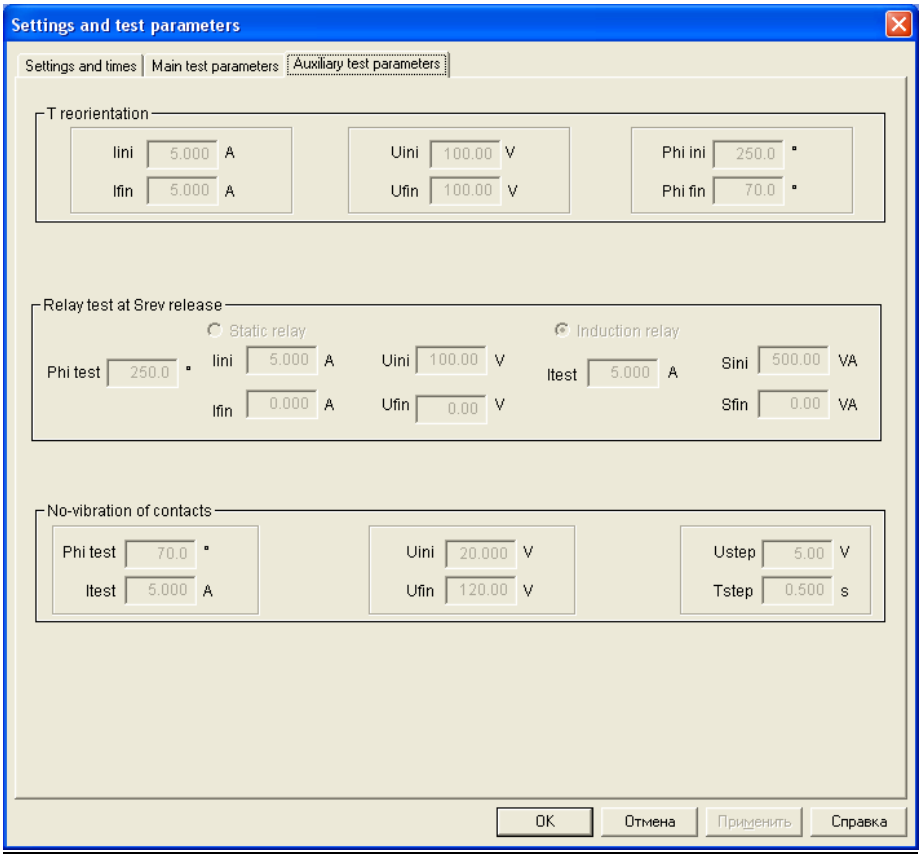


Figure 3.6.4 – Settings and test parameters window. *Auxiliary test parameters* tab

3.6.5 Test Algorithm

Test parameters can be different for every tested power direction relay. Test parameters values entered into editable windows by default, are connected with parameters specified in the *Settings and time* window. During the test RETOM outputs test voltage from U_C channel and test current from I_A channel. Voltage channels U_A and U_B, if necessary, are used for relay supply (DC or AC operating voltage).

The program allows to test the following relay parameters:

1) No-current running

The test (relay is only supplied with current, no voltage) is carried out with set step I_{STEP} in the I_{INI} to I_{FIN} current range.

2) No-voltage running

The test (relay is only supplied with voltage, no current) is carried out with set step U_{STEP} within U_{INI} – U_{FIN} voltage range which are changing automatically and sustained within specified fault time of every step.

3) Characteristic angle φ_{CHAR} test

The test is carried out by default at specified current and voltage (as a rule, I_{RATED} and U_{RATED}). Test technique is the same as for impedance relay. The test starts with voltage/current angle equal to φ_{CHAR}+180°. Current/voltage angle changes with step 4*$\Delta\varphi$ (roughly) clockwise. When relay operation angle is found, operating area side and angle φ_1 are determined more precisely with angle $\Delta\varphi$ set step. Then direction of φ variation changes (counterclockwise) and another operating area side and angle φ_2 are determined in the same way. Relay operating area is not specified in the technical data and should be estimated by the user. In all cases this area should not exceed 180^0.

4) Operation voltage U_{op} and operation power S_{op} test

U_{OP} , S_{OP} as well as voltage reset ratio test is carried out by U variation from U_{MIN} до U_{MAX} with set step φ_{TEST} and specified test current I_{TEST} (as a rule I_{TEST}=I_{RATED}). S_{OP} is calculated. To test U_{RES} *и* S_{RES} the voltage at which the relay contact switches is doubled in order to avoid relay contact bounce (relay contact is pressed) and then voltage decreases at a set step. U_{RES} is determined, S_{RES} is calculated.

Voltage reset ratio is not compared with the specified one, but it is logged to Protocol.

5) Operation current I_{OP} test

I_{OP}, I_{RES} as well as reset ratio test is carried out at U_{TEST} set voltage and φ_{CHAR} angle by current variation from I_{MIN} to I_{MAX} with ΔI current step.

6) Operating, reset and reorientation time test

The test is carries out at φ_{CHAR} by voltage stepwise variation for induction relays or voltage and current - for static relays (i.e. by power variation). Reorientation time test is carried out in the same way, but the voltage/current angle changes from φ_{INI} to φ_{FIN}.

7) Relay test at reverse power (S_{REV}) shedding

The test is carried out provided the relay is used in a directional stage operating without time delay. S_{REV} reverse power shedding value is set by the dispatching service as the max fault power “behind the back” (is entered into the *Settings and time* window). The test is performed at voltage/current angle equal to φ_{CHAR}+180°, at specified current by power shedding from S_{INI} to S_{FIN}. The relay should not operate.

8) No contact vibration test

The test is carried out automatically at φ_{CHAR} (fault within operating area), at specified test current (as a rule max fault current near bus). The power is changed from S_{INI} to S_{FIN} by voltage variation from U_{INI} to U_{FIN} with set voltage step. Two switches-over of the relay contact mean vibration.

4.6.6 Test Protocol

The test results are registered in a protocol. The test protocol window and comments are shown in Figure 3.6.5.

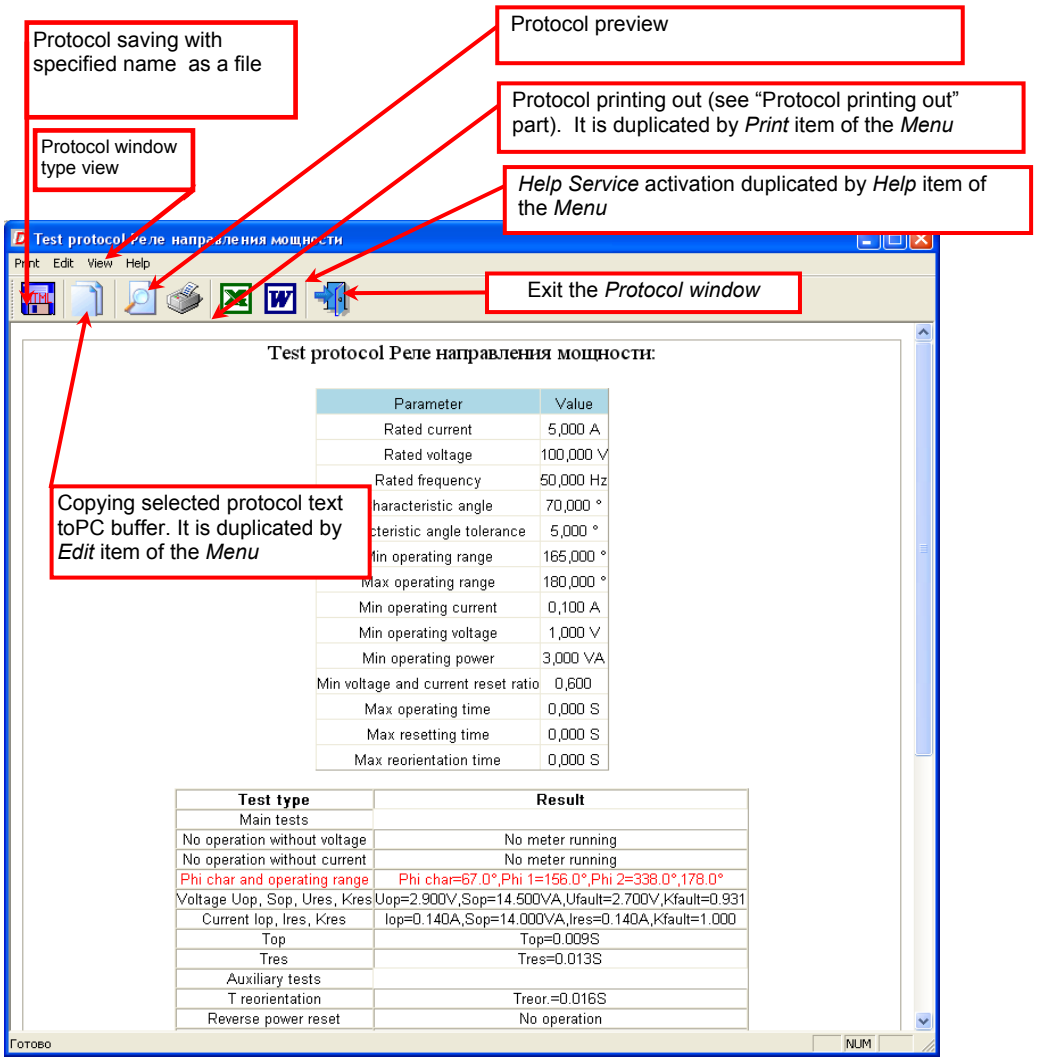

Protocol saving with specified name as a file
Protocol preview
Protocol window type view
Protocol printing out (see “Protocol printing out” part). It is duplicated by *Print* item of the *Menu*
Help Service activation duplicated by *Help* item of the *Menu*
Test protocol Реле направления мощности
Print Edit View Help
Exit the *Protocol window*
Copying selected protocol text toPC buffer. It is duplicated by *Edit* item of the *Menu*
Test protocol Реле направления мощности:
Parameter | Value
Rated current | 5,000 A
Rated voltage | 100,000 V
Rated frequency | 50,000 Hz
haracteristic angle | 70,000 °
cteristic angle tolerance | 5,000 °
in operating range | 165,000 °
Max operating range | 180,000 °
Min operating current | 0,100 A
Min operating voltage | 1,000 V
Min operating power | 3,000 VA
Min voltage and current reset ratio | 0,600
Max operating time | 0,000 S
Max resetting time | 0,000 S
Max reorientation time | 0,000 S
Test type | Result
Main tests
No operation without voltage | No meter running
No operation without current | No meter running
Phi char and operating range | Phi char=67.0°,Phi 1=156.0°,Phi 2=338.0°,178.0°
Voltage Uop, Sop, Ures, Kres | Uop=2.900V,Sop=14.500VA,Ufault=2.700V,Kfault=0.931
Current Iop, Ires, Kres | Iop=0.140A,Sop=14.000VA,Ires=0.140A,Kfault=1.000
Top | Top=0.009S
Tres | Tres=0.013S
Auxiliary tests
T reorientation | Treor.=0.016S
Reverse power reset | No operation
Готово
NUM

Figure 3.6.5 – *Test protocol* window

3.7 Automatic Frequency Relay Test

3.7.1 Application

The program is intended for automatic test of frequency relays both of old types and contemporary microprocessor relays which respond not only to frequency value but also to ΔF/Δt frequency variation rate.

3.7.2 Program Start

To start the program the *Frequency Relay* icon ( ) in RETOM-51 program main window is used. Program work window and necessary comments are given in Figure 3.7.1.

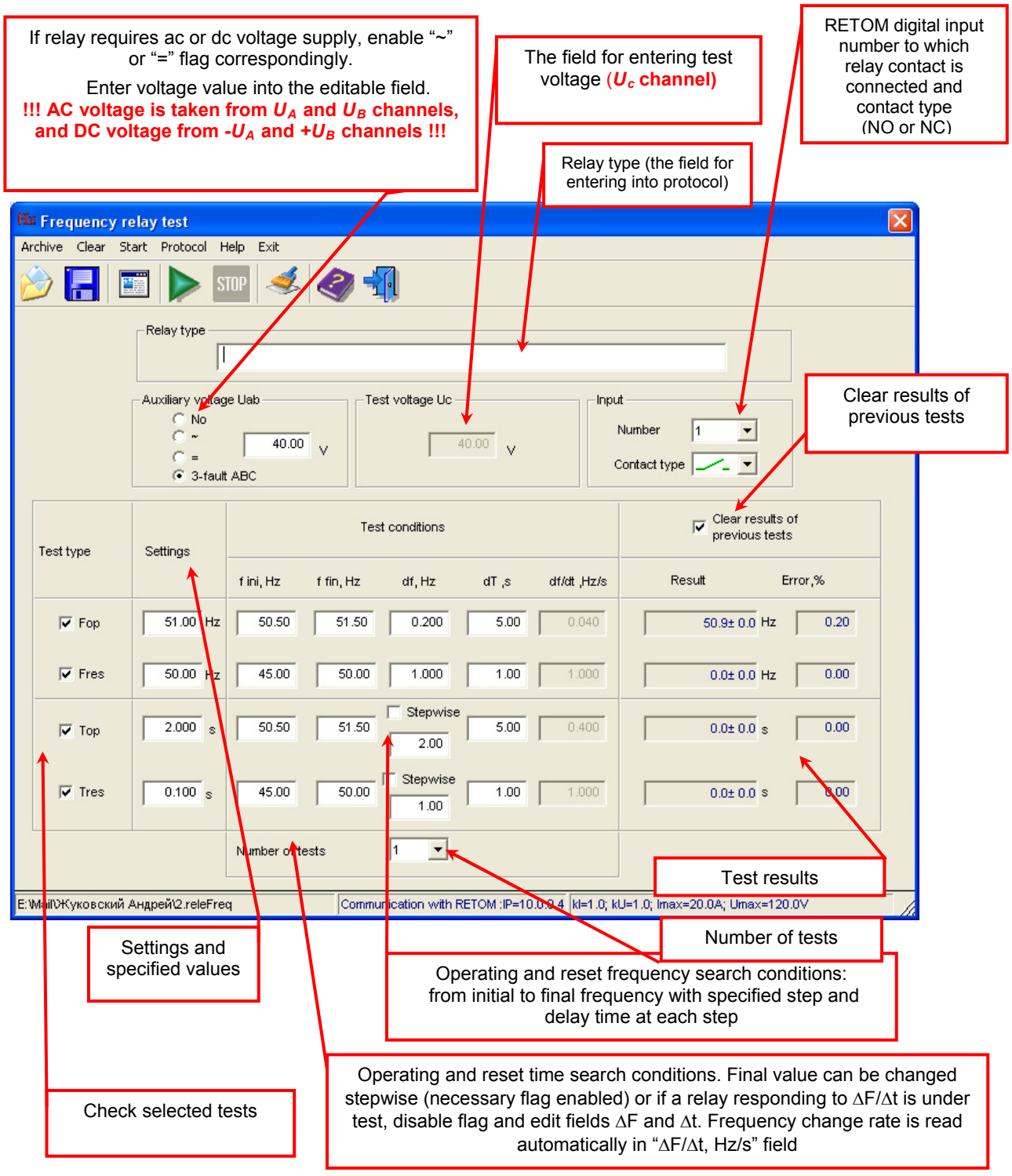

If relay requires ac or dc voltage supply, enable "~" or "=" flag correspondingly.
Enter voltage value into the editable field.
!!! AC voltage is taken from U_A and U_B channels, and DC voltage from -U_A and +U_B channels !!!
The field for entering test voltage (U_c channel)
Relay type (the field for entering into protocol)
RETOM digital input number to which relay contact is connected and contact type (NO or NC)
Clear results of previous tests
Frequency relay test
Archive Clear Start Protocol Help Exit
STOP
Relay type
Auxiliary voltage Uab
No
~
=
3-fault ABC
40.00 V
Test voltage Uc
40.00 V
Input
Number 1
Contact type
Test type
Settings
Test conditions
f ini, Hz
f fin, Hz
df, Hz
dT ,s
df/dt ,Hz/s
Result
Error,%
Clear results of previous tests
Fop 51.00 Hz 50.50 51.50 0.200 5.00 0.040 50.9± 0.0 Hz 0.20
Fres 50.00 Hz 45.00 50.00 1.000 1.00 1.000 0.0± 0.0 Hz 0.00
Top 2.000 s 50.50 51.50 Stepwise 2.00 5.00 0.400 0.0± 0.0 s 0.00
Tres 0.100 s 45.00 50.00 Stepwise 1.00 1.00 1.000 0.0± 0.0 s 0.00
Number of tests 1
E:\Mail\Куковский Андрей\2.releFreq
Communication with RETOM :IP=10.0.0.4
kI=1.0; kU=1.0; Imax=20.0A; Umax=120.0V
Test results
Number of tests
Settings and specified values
Operating and reset frequency search conditions: from initial to final frequency with specified step and delay time at each step
Operating and reset time search conditions. Final value can be changed stepwise (necessary flag enabled) or if a relay responding to ΔF/Δt is under test, disable flag and edit fields ΔF and Δt. Frequency change rate is read automatically in "ΔF/Δt, Hz/s" field
Check selected tests

Figure 3.7.1 – *Automatic Frequency relay test* program work window

3.7.3 How to Work with the Program

The upper part of the program work window contains *Toolbar* buttons (Figure 3.7.2).

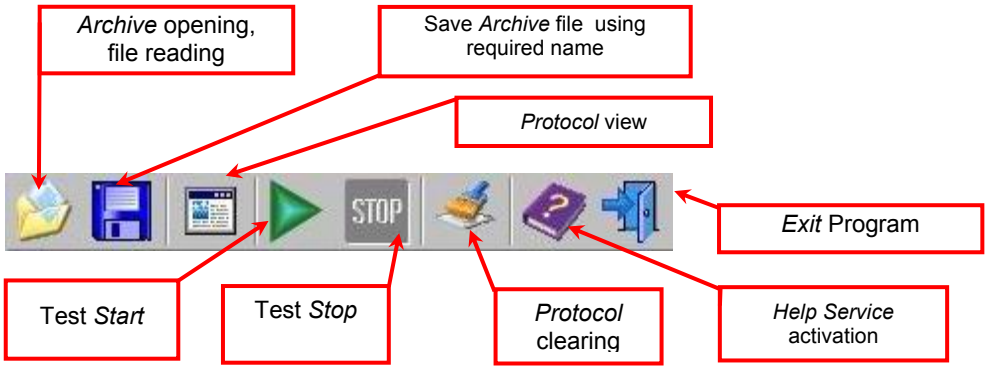


Figure 3.7.2 – *Toolbar* buttons

Archive description is given in section “Archive Handling” .

The protocol is completed according to test results. The *Test protocol* window and comments are shown in Figure 3.7.3.

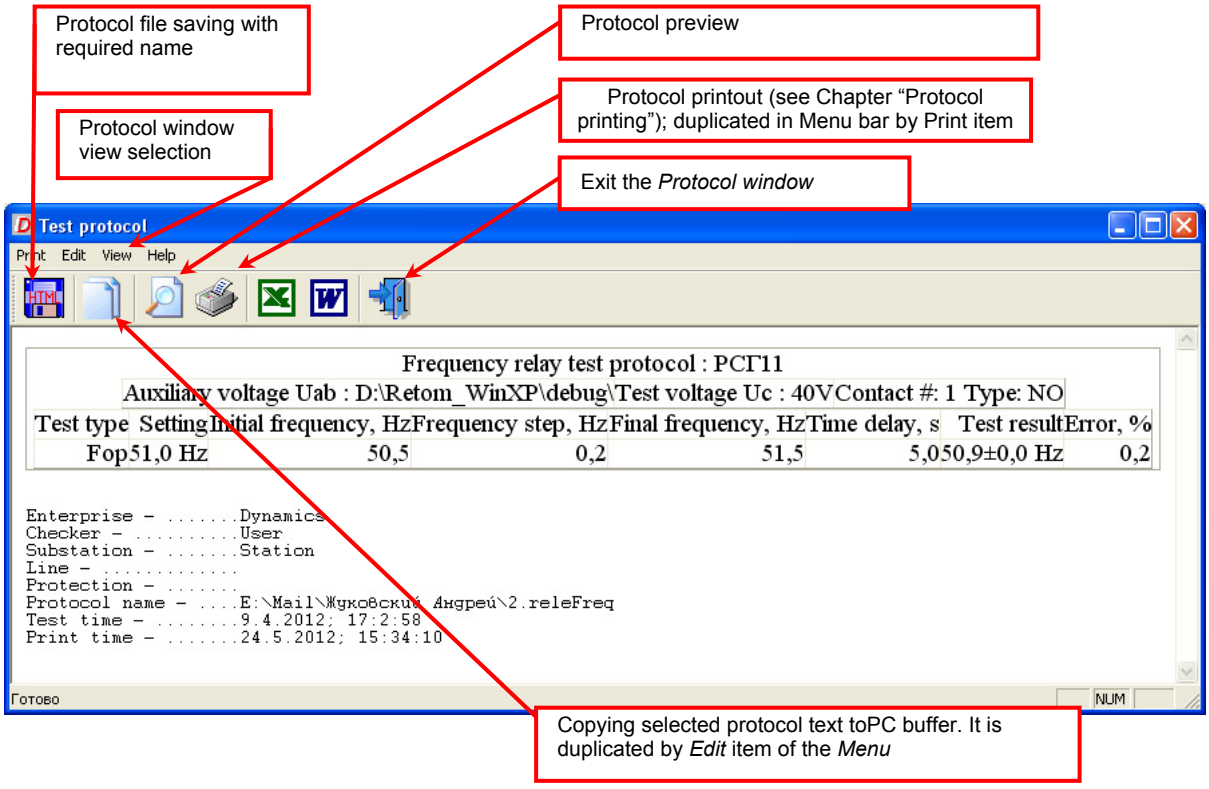

Protocol file saving with required name
Protocol window view selection
Protocol preview
Protocol printout (see Chapter “Protocol printing”); duplicated in Menu bar by Print item
Exit the *Protocol window*
Test protocol
Print Edit View Help
Frequency relay test protocol : PCT11
Auxiliary voltage Uab : D:\Retom_WinXP\debug\Test voltage Uc : 40VContact #: 1 Type: NO
Test type Setting Initial frequency, Hz Frequency step, Hz Final frequency, Hz Time delay, s Test result Error, %
Fop 51,0 Hz 50,5 0,2 51,5 5,0 50,9±0,0 Hz 0,2
Enterprise – .....Dynamics
Checker – .....User
Substation – .....Station
Line – .....
Protection – .....
Protocol name – ....E:\Mail\Жуковский Андрей\2.releFreq
Test time – 9.4.2012; 17:2:58
Print time – 24.5.2012; 15:34:10
Готово
NUM
Copying selected protocol text toPC buffer. It is duplicated by *Edit* item of the *Menu*

Figure 3.7.3 – Protocol window

View menu item contains commands for showing and hiding *Toolbar* and *Status* bar of the *Protocol* window. All necessary test parameters are saved in the Protocol (protection, options, settings, test conditions, test results etc.).

To test frequency relay specify relay settings and test parameters (conditions). Necessary Options are entered and an Archive file opens (or new one will be created) where you can save all test parameters. After specifying all parameters, push the <*Start*> button. The test can be stopped, if necessary, by pressing the <*Stop*> button.

The protocol should be saved into the *Archive* by pressing <*Save as*> button ( ) on test completion.

3.8 Automatic Distance Protection and Impedance Relay Test

3.8.1 Application

The program is designed to test distance protection and impedance relay automatically. It allows to test multi-zone (up to 5 zones) distance protection, to determine max. sensitivity angle, impedance setting, eccentricity, accurate impedance relay operation current, to perform complex protection test.

3.8.2 Program Start

To start the program the *Distance Relay test* icon ( ) in RETOM-51 program main window is used. After program start the main window will be displayed (see Figure 3.8.1).

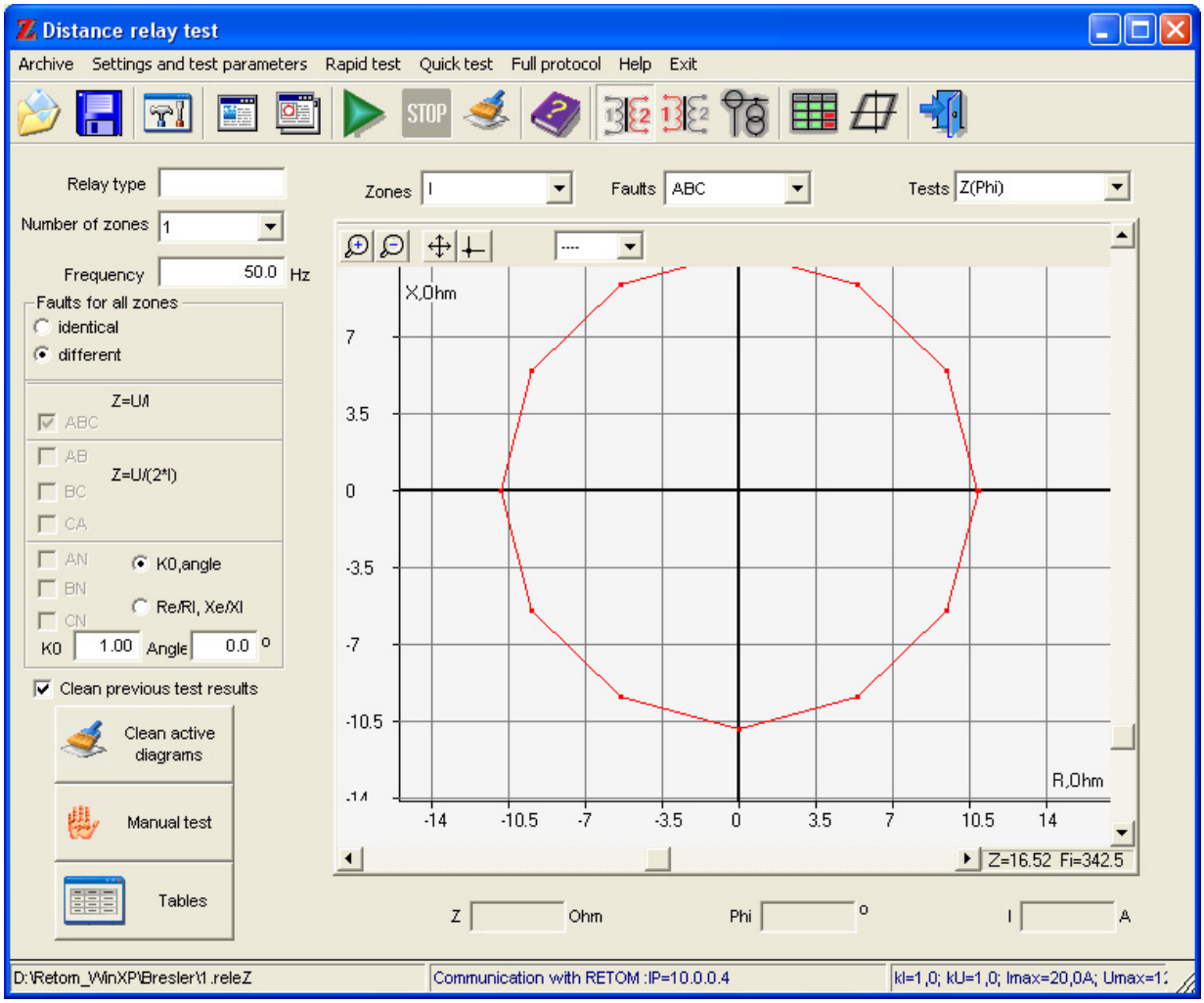


Figure 3.8.1 – *Impedance relay* test program main window

3.8.3 How to Work with the Program

The main window contains:

- menu bar;
- toolbar;
- status line.

During tests, if the window is minimized, its header shows the actual test status. In this case the window looks like this:

The window header contains:

- zone No.;
- fault type;
- test type.

Menu

The menu includes the following items:

- *Archive*:
  - *Open* – open the archive file (see chapter "*Archive handling"*);
  - *Save* – save data into the archive (see chapter "*Archive handling*");
- *Settings and test parameters* – call of settings and test parameters taskbar;
- *Rapid test* – call of rapid test window (Z search with relevant angle);
- *Quick test* – call of quick test window (Z check with relevant angle);
- *Full protocol* – printable protocol preview;
- *Help – Help Service* activation;
- *Exit* - program exit.

Toolbar

Toolbar is shown in Figure 3.8.2.

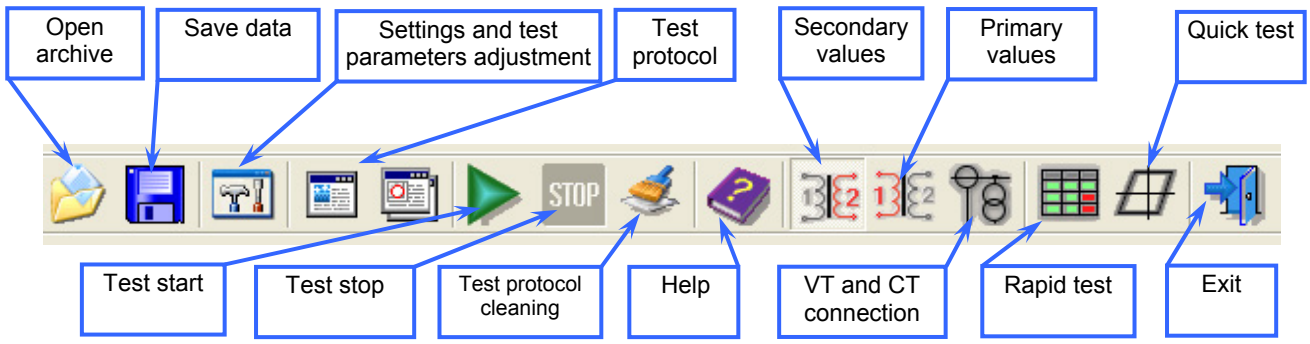


Figure 3.8.2 – *Toolbar* buttons

Buttons function:

- <*Open Archive*> - open archive file (chapter "*Archive handling*");
- <*Save Data*> - save data into Archive (chapter "*Archive handling*";
- <*Settings and test parameters adjustment*> - call of settings and test parameters adjustment window;
- <*Test Protocol*> - protocol printable preview;
- <*Test start*> - selected tests start. After test start the button image changes to and by pressing this button the test stops until next pressing;
- <*Test stop*> - the button is enabled only during testing;
- <*Test protocol cleaning*> - by pressing this button all test results are deleted, but test parameters are saved;
- <*Help*> - *Help Service* activation;
- <*Secondary values*> - for Z impedance parameters setting using secondary values;
- <*Primary values*> - for Z impedance parameters setting using primary values;
- <*VT and CT connection*> - for connection via VT and/or CT;
- <*Quick test*> - call of "Quick test" mode;
- <*Rapid test*> - call of "Rapid test" mode;
- <*Exit*> - program exit.

Status bar

The *Status bar* looks like the following:

The *Status* bar contains the following data:

- open Archive name;
- port status (during testing – the current state of the test is shown here);
- max allowable output data values.

Work window elements

The main part of the window (Figure 3.8.3) contains the following elements:

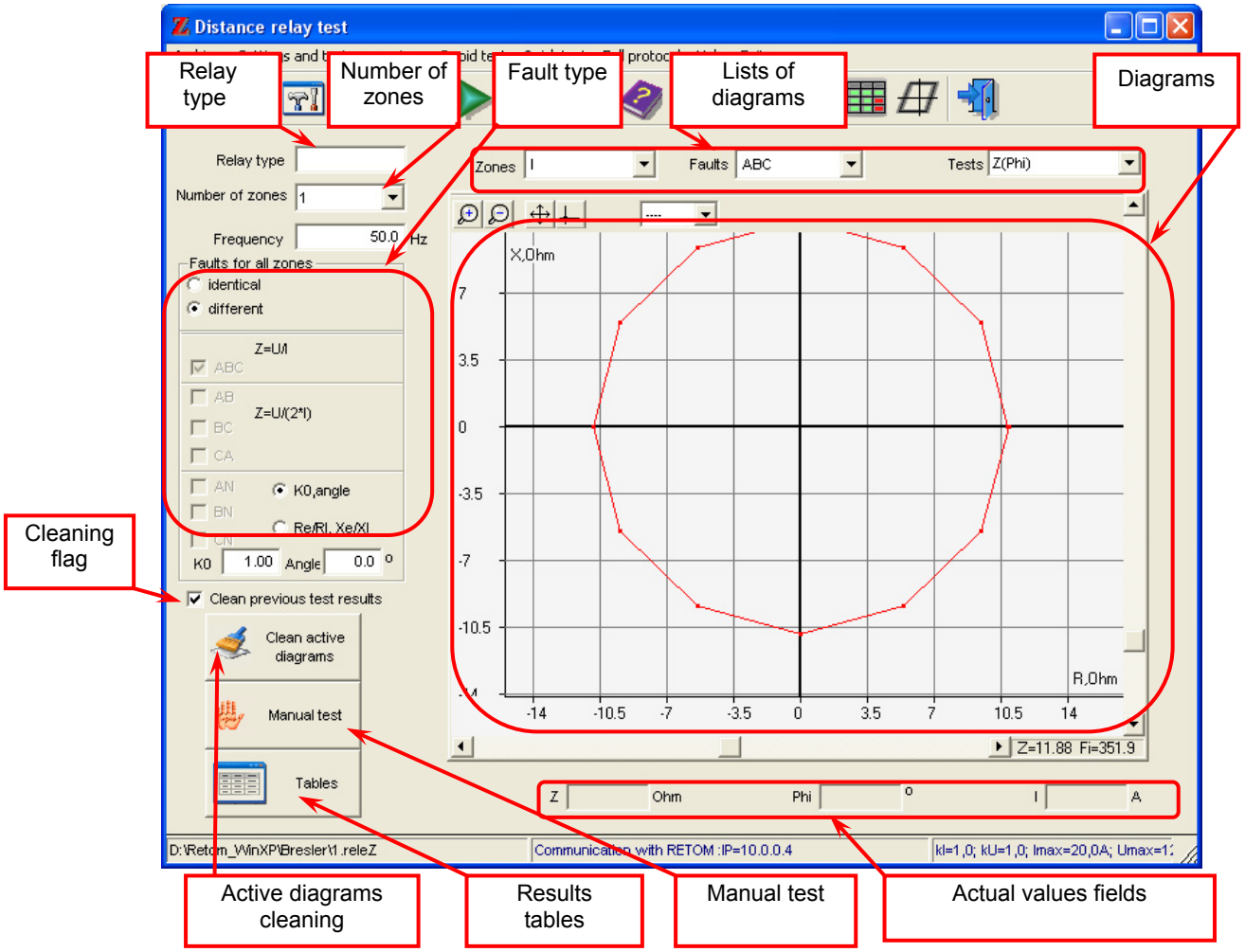


Figure 3.8.3 – *Impedance relay* test program window

- *Relay type* - Protection type is specified. It is registered in the test protocol;
- *Number of zones* - Number of zones in the protection being tested;
- *Fault types* - Fault types selection. Fault types can be the same for all zones or different ones;
- *Cleaning flag* - Serves to clean all previous test results. If it is necessary to register auxiliary tests results in the current protocol, disable the flag. If the flag is enabled, all results of available tests are cleaned and tests start again by pressing "*Test start*" button. The flag is enabled by default;
- *Active diagrams cleaning* - To clean all diagrams displayed on the screen;
- *Manual test* - The program allows carrying out either manual or automatic tests. To go to the manual test mode press the *Manual Test* button, which calls manual test window. The detailed description of this test is given below;
- *Tables results* - This button is enabled only if test results are available. The tables of all results saved in the archive are displayed by pressing this button;
- *Diagrams* - Displayed diagram types are selected from the lists located directly above the diagrams. Diagrams lists contain zone number list, fault type list, test type list. Several values can be selected in number of zones and fault types lists simultaneously. Only one element would be selected from test types list. Directly under the diagram there are actual values during tests.

Pauses in program

When it is required to stop a test for some time (e.g. for electromechanical panels) press *Pause* button. To continue the test press *Start* button.

Rapid test

Rapid test permits to determine Z operation for the required angle when the fault type is specified.

To call this test it is necessary to select *Rapid test* item in main window. The following window will be displayed (Figure 3.8.4).

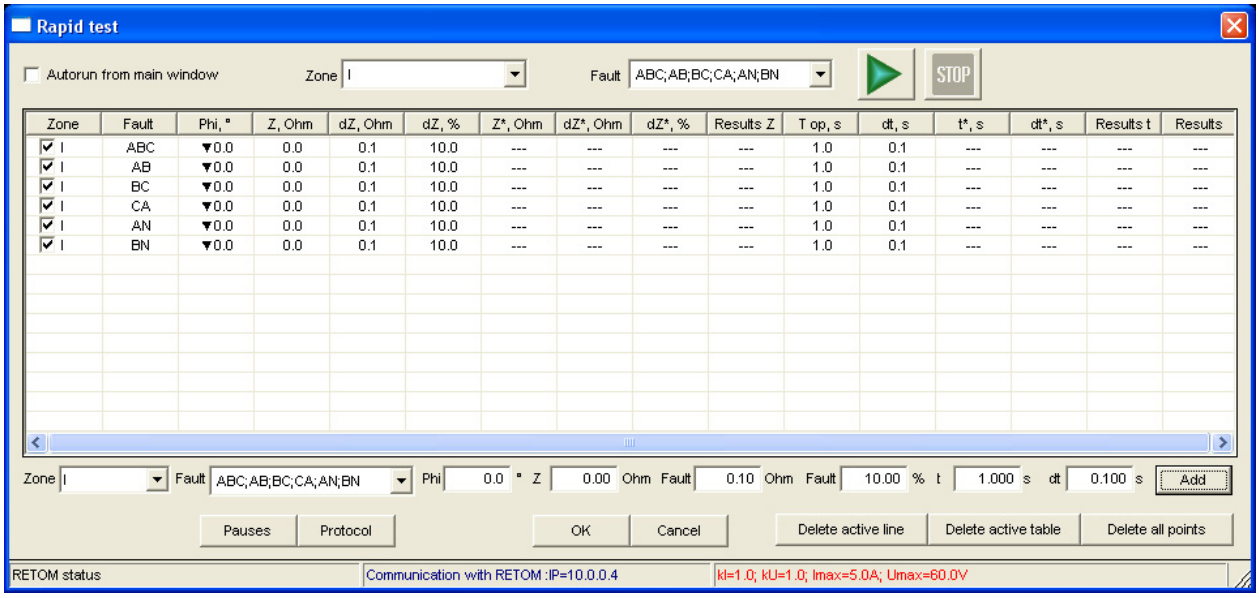

Rapid test
Autorun from main window
Zone I
Fault ABC;AB;BC;CA;AN;BN
STOP
Zone | Fault | Phi, ° | Z, Ohm | dZ, Ohm | dZ, % | Z*, Ohm | dZ*, Ohm | dZ*, % | Results Z | T op, s | dt, s | t*, s | dt*, s | Results t | Results
I | ABC | ▼0.0 | 0.0 | 0.1 | 10.0 | --- | --- | --- | --- | 1.0 | 0.1 | --- | --- | --- | ---
I | AB | ▼0.0 | 0.0 | 0.1 | 10.0 | --- | --- | --- | --- | 1.0 | 0.1 | --- | --- | --- | ---
I | BC | ▼0.0 | 0.0 | 0.1 | 10.0 | --- | --- | --- | --- | 1.0 | 0.1 | --- | --- | --- | ---
I | CA | ▼0.0 | 0.0 | 0.1 | 10.0 | --- | --- | --- | --- | 1.0 | 0.1 | --- | --- | --- | ---
I | AN | ▼0.0 | 0.0 | 0.1 | 10.0 | --- | --- | --- | --- | 1.0 | 0.1 | --- | --- | --- | ---
I | BN | ▼0.0 | 0.0 | 0.1 | 10.0 | --- | --- | --- | --- | 1.0 | 0.1 | --- | --- | --- | ---
Zone I Fault ABC;AB;BC;CA;AN;BN Phi 0.0 ° Z 0.00 Ohm Fault 0.10 Ohm Fault 10.00 % t 1.000 s dt 0.100 s Add
Pauses
Protocol
OK
Cancel
Delete active line
Delete active table
Delete all points
RETOM status
Communication with RETOM :IP=10.0.0.4
kI=1.0; kU=1.0; Imax=5.0A; Umax=60.0V

Figure 3.8.4 – *Rapid test* window

Rapid test mode permits to set test points (Z search points) in Z plane for each zone and fault type. For every point module and angle of Z impedance, accuracy of Z in absolute values and percent are to be specified. In addition, protection operating time and allowable time deviation are to be set.

After the test the table is filled with values obtained. According to the results obtained a *Results Z* column (whether results obtained satisfy the requirements) for Z impedance and *Results t* column for time are filled. If the deviation of the value obtained is less than admissible error, the corresponding cell becomes green highlighted with «*OK*» inscription. Otherwise it becomes red highlighted.

Z status is considered to be normal, if at least one of the deviations (absolute or percent) is normal.

The cell in the last column gets green if deviations of Z and t obtained values are within admissible error limits.

The test protocol is called and printed out separately after pressing the *Protocol* button of this window.

The test current is taken from general *Test parameters* (Z(φ) curve recording).

Quick test

This test allows to test quickly the Z accuracy with the set factors at the given angle and specified fault types.

To call this test select the *Quick test* menu item in the main window. The window shown in Figure 3.8.5 will be displayed.

Quick test differs from *Rapid test* in that the Z value is not searched with every angle but is tested with the given factors *K1* and *K2* (usually 0.95 and 1.05), Z-characteristics sides are also tested with the help of φ> and φ< type of search. In other words, to estimate Z accuracy only two iterations are performed and operation within the zone and no operation beyond the zone are recorded. This makes the test much quicker and saves resources of, in particular of electromechanical panels.

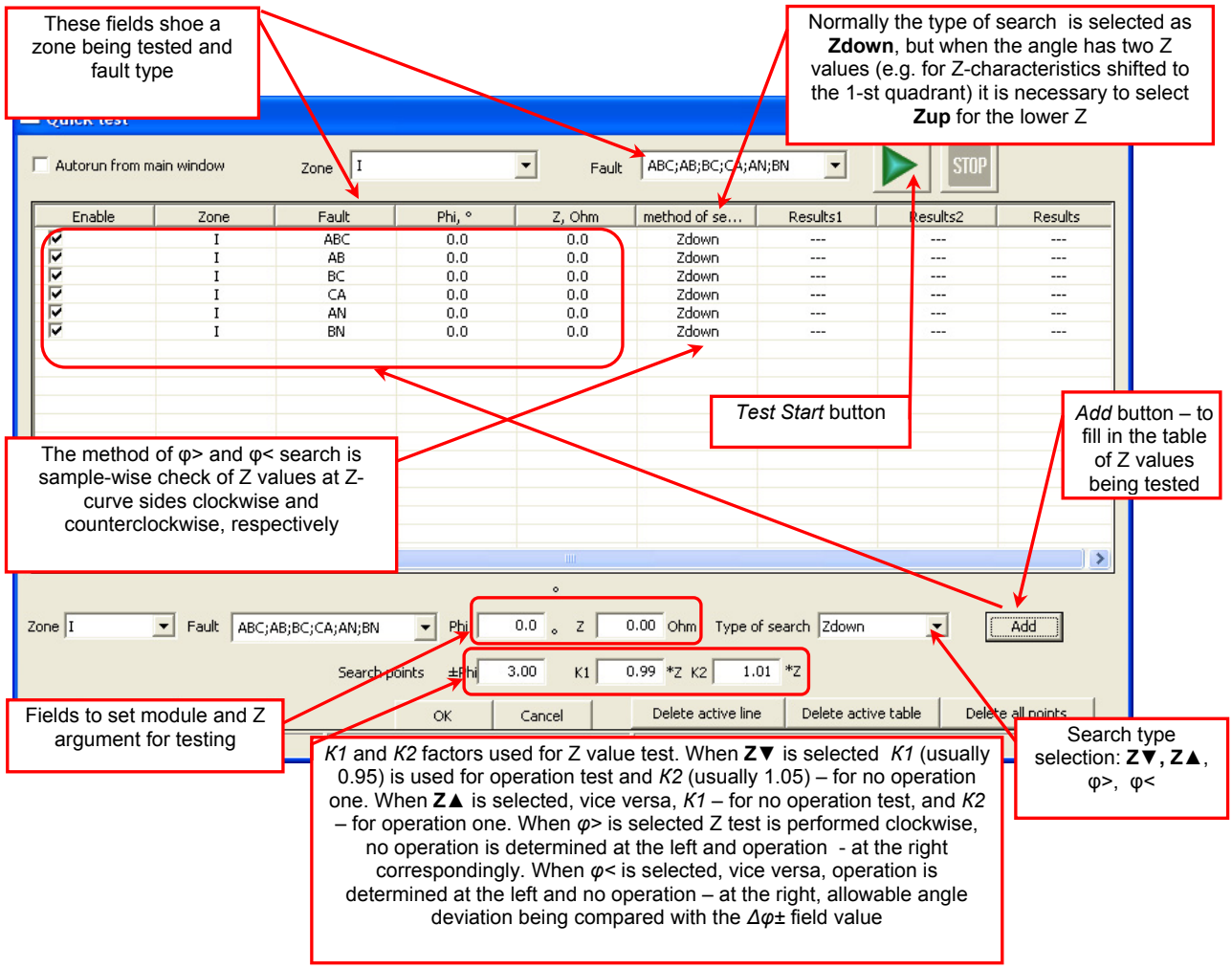

These fields shoe a zone being tested and fault type
Normally the type of search is selected as **Zdown**, but when the angle has two Z values (e.g. for Z-characteristics shifted to the 1-st quadrant) it is necessary to select **Zup** for the lower Z
Autorun from main window
Zone
Fault
ABC;AB;BC;CA;AN;BN
STOP
Enable
Zone
Fault
Phi, °
Z, Ohm
method of se...
Results1
Results2
Results
Test Start button
Add button – to fill in the table of Z values being tested
The method of φ> and φ< search is sample-wise check of Z values at Z-curve sides clockwise and counterclockwise, respectively
Phi
Z
Ohm
Type of search
Zdown
Add
Search points
±Phi
3.00
K1
0.99
*Z
K2
1.01
*Z
OK
Cancel
Delete active line
Delete active table
Delete all points
Fields to set module and Z argument for testing
Search type selection: Z▼, Z▲, φ>, φ<
K1 and K2 factors used for Z value test. When Z▼ is selected K1 (usually 0.95) is used for operation test and K2 (usually 1.05) – for no operation one. When Z▲ is selected, vice versa, K1 – for no operation test, and K2 – for operation one. When φ> is selected Z test is performed clockwise, no operation is determined at the left and operation - at the right correspondingly. When φ< is selected, vice versa, operation is determined at the left and no operation – at the right, allowable angle deviation being compared with the Δφ± field value

Figure 3.8.5 – Quick test window

After the test the table is filled with values obtained. According to the results of values obtained the *Status* column (whether results obtained satisfy the requirements) for Z impedance is filled. If the deviation of the value obtained is less than admissible error, in the corresponding green highlighted cell «*OK*» inscription will appear. Otherwise the cell be red highlighted.

The current test is taken from general *Test parameters* (Z(φ) curve recording).

Manual test

Manual test window (Figure 3.8.6) is called by pressing *Manual Test* button from the *Impedance relay* test program.

Manual test mode is suitable for setting distance protection or to find out reasons of impossibility to perform automatic tests.

It is available to select fault type, to set fault current and voltage manually in this window. Also Z impedance module and its angle can be set here. Depending on the set values phase currents and voltages are recalculated and specified Z impedance value is displayed in the diagram and *R* and *X* fields as well. Protection operation being tested is indicated on the binary inputs panel.

The manual mode permits also to measure operating and reset time of protection. For that it is necessary to select *Time lag meter* as an active instrument.

To activate set current and voltage delivery switch on the *Program switch*.

To return to the automatic test mode press ✕ button at the upper right corner of the window.

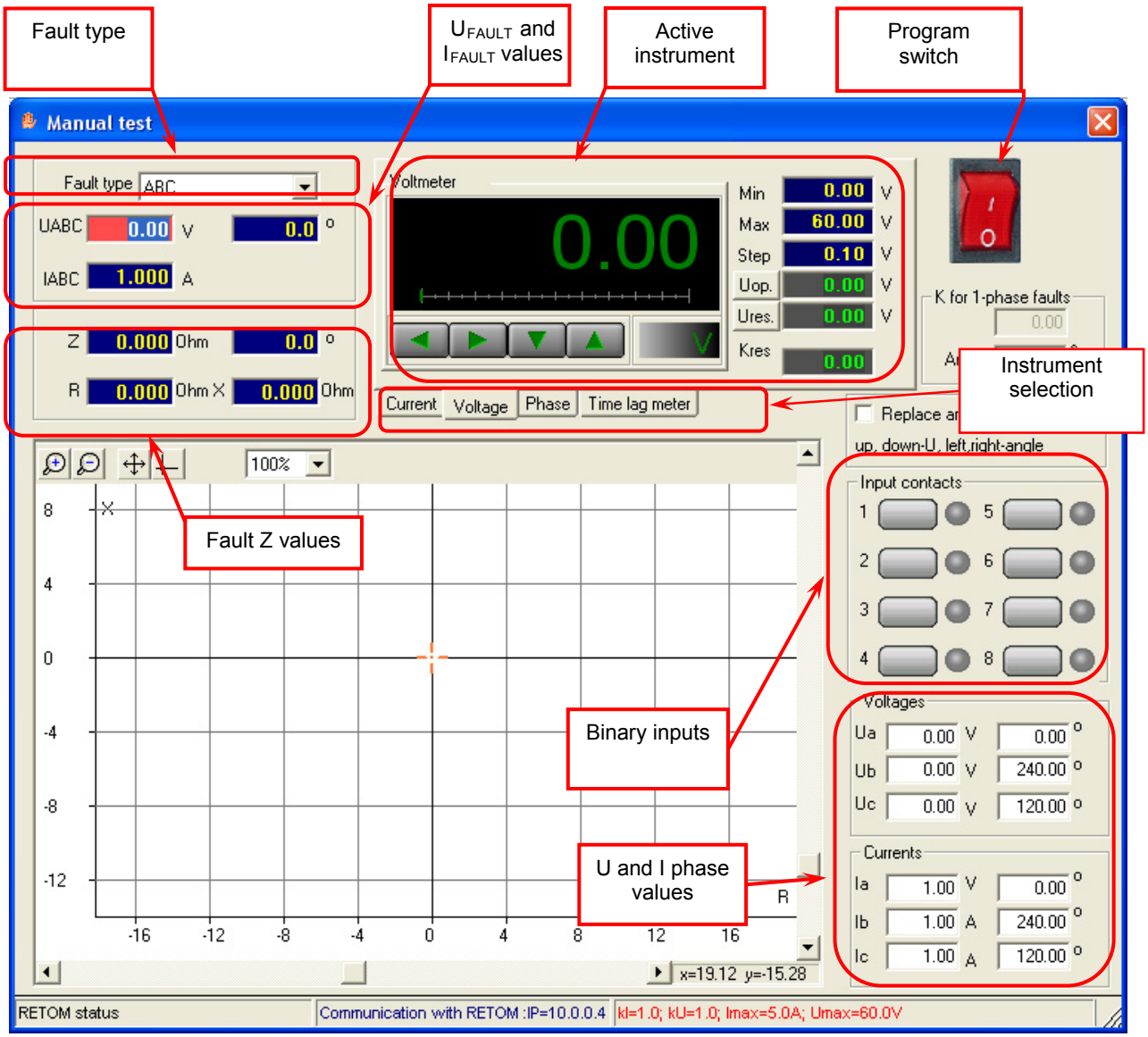


Figure 3.8.6 – Manual test

3.8.4 Test Algorithm

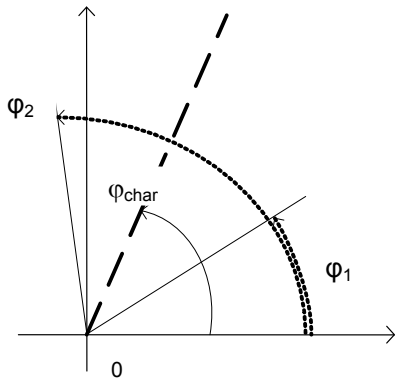
The program allows to perform the following tests:

1) φ_{CHAR} (relay characteristic angle) test.

The test is carried out for each selected zone and fault type. Input data for the test is:

- test current;
- φ step;
- Z ratio.

The test is carried out at constant impedance: $Z=Z_{SET}*(Z_{RATIO})$, i.e. at the test circle having the center in the origin of coordinates (see Figure below). The test begins from the angle opposite to the angle specified in settings with $\Delta\varphi$*10 step. φ1 and φ2 operating angles are determined at the zone boundary, i.e. at intersection of characteristic and circle being tested. To obtain more precise relay operating angle the program makes a backward step after entering the operating area, reduces φ angle step by 10 automatically and then finds more precise values of φ1 and φ2:



Using these data the program determines φ_{char}:

$\varphi_{CHAR} = (\varphi_1 + \varphi_2)/2$,

where φ_{CHAR} – relay characteristic angle.

2) Z_{SET} impedance test

This test is carried out at φ_{char} angle, set in the *Settings*. Test current is set in *Test parameters*. Point search is made by sequential Z descent beginning with Z_{SET}*1.2. First run search is carried out stepwise with (Z_{SET}*1.2)/10 step. If at Z impedance relay operation is occurred the computation of new ΔZ step is made.

$$\Delta Z = Z^*(Z_{ACCURACY})$$

After this the function makes backstep and test repeats with ΔZ step.

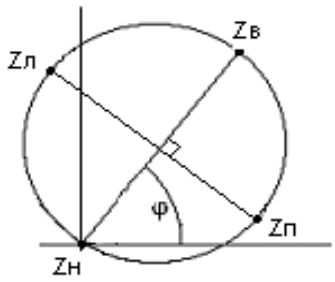
3) Bias search

Depending on the bias type (into operating area or “behind the back”) point search is curried out “up” at the angle φ specified in *Settings* or “down” at the $\varphi+180^0$ angle respectively. Point search is carried out according to the algorithm described above (see Z_{SET} impedance test).

4) Eccentricity search

Point search is carried out “up” (Z_B) and “down” (Z_H) at φ angle specified in *Settings*.

After that the line perpendicular to characteristic line and passing through the (Zв + Zн)/2 point is to be found. Along this line points are searched from the right (Zп) and from the left (Zл).



The following values are entered into the table:

- major semiaxis – line length ($Z_в$-$Z_н$);
- minor semiaxis – line length ($Z_п$-$Z_л$);
- minor semiaxis / major axis ratio.

5) Z(φ) characteristic

Trip points search is carried out for each angle beginning from initial one (φ) with $\Delta\varphi$ step using sequential descent method or halving method according to set parameters. Taking of the characteristic is completed when the last point at φ_{FIN} has been found. At initial angle Z point search begins from the value:

- 1,2 Z_{SET} – when using sequential descent method;
- 1,2/2 Z_{SET} – when using halving method.

When testing subsequent angles the impedance is bound to $Z_{OPER\ PREV}$. the previous trip point and equals to:

- 1,2 $Z_{OPER\ PREV}$ – when using sequential descent method;
- 1,2/2 $Z_{OPER\ PREV}$ – when using halving method.

If refinement at the knee-point search technique is used for test, then if the angle difference module |φ1- φ2| between two lines connecting three previous points is more than 10°, point search starts with a $\Delta\varphi$/10 step from

the previous angle (see Settings and test parameters window, point search method - refinement at the knee-point search).

If necessary, operating area side search is possible by setting marks. Point detection is performed at constant impedance module $Z=KZ_{SET}$ and angle change.

At every angle points are searched “up” and “down”.

If protection does not operate at some angle, depending on the set point search technique, Z_{op} is searched:

- from last found point at every angle;
- operation to 0 at every angle.

6) Precision operating current search

Fault current changes from I_{ini} to I_{fin} with step ΔI. During test procedure the φ angle is constant and is equal to φ_{CHAR} angle defined by settings. At each step the current reduces into ΔI and Z_{op} is found. Test continues until Z becomes lower than $Z_{SET}*(Z_{RES})$. Then a jump to previous current occurs, current step reduces by 10 and more precise $I_{\underline{ACCUR}}$ current (at which $Z_{OP} > Z_{SET}*Z_{RES}$) search starts.

7) Taking the reading of zone T(Z) characteristic.

Operating time test starts from Z = 0 with $\Delta Z = Z_{MAX} * (Z\%$ step). When actual and previous operating time difference is greater than that one specified in test parameters, the return to the previous step and taking of reading of the characteristic with smaller step ($\Delta Z/10$) take place.

Arg(Z) during this test is constant and it is specified in test parameters.

Pulse time for this test shall be equal to *Pulse* time for the last zone.

Test current for each zone equals to that at which reading of the Z(φ) characteristic is taken.

From all has been sail it follows that to take the reading of the zone characteristic correctly it is required to know for each zone the test current and Pulse time during testing the last zone.

8) Test from “memory”.

In this test during XX time for the first zone a three-phase symmetrical current and voltage system (I = 0, U = 57.73 V) is given. When the XX time expires a three-phase fault is simulated (fault current is specified in test parameters, $U_{FAULT} = 0$, $\varphi_{FAULT} = \varphi_{CHAR}$). During fault imitation operating time and duration of closed state of the selected contact are registered.

3.8.5 Settings and Test Parameters Window

This window appears when selecting *Settings and test parameters* item or by pressing *Test parameters and settings adjustment* button of the toolbar.

This window is intended to set settings and test conditions for each zone. The number of tabs in the window equals to the number of zones set in the main window and also “*Complex”* tab intended for complex test. All the tabs, from the first to the last one, look similar. The last tab is used for setting *Complex test* parameters. The window and comments are shown in Figure 3.8.7.

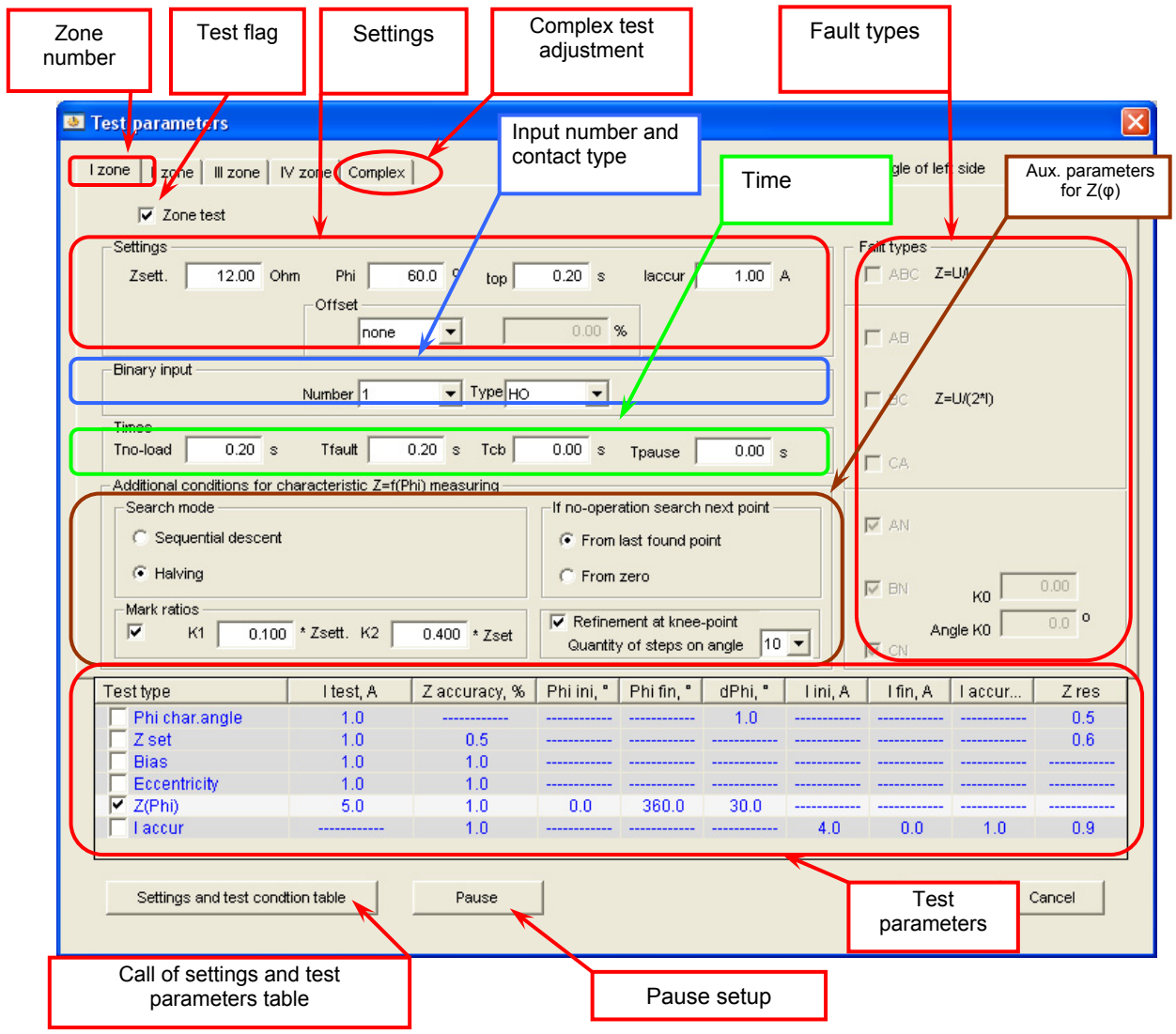


Figure 3.8.7 – Settings and test parameters window

Test for any zone

Test flag ☑ is selected for each zone to be tested. If the flag is enabled, all tests selected for the given zone are performed, otherwise are not.

The following data may be set for each stage:

1) Settings:

- Z_{sett};
- φ – Line or relay characteristic angle;
- t_{op} - Operating time for the given zone;
- I_{accur} - Accurate operation current;
- Offset (Bias) type (into operating area or “behind the back”) and its percentage.

2) Test parameters. All necessary tests to be carried out should be flagged in the test parameters window. All necessary test parameters should be also set here:

a) For φ_{CHAR} (relay characteristic angle) search:

- test current (I_{test});
- Δφ (dPhi) - angle step. During first run the area boundaries are determined with accuracy up to 10*Δφ. After this a return to previous angle step occurs and the boundaries are determined with accuracy up to Δφ;
- Z ratio (Z_{RES}) - φ_{CHAR} test is carried out at constant $Z = Z_{SET} * Z_{RES}$;

b) For Z_{SET} impedance search:

- test current (I_{test});
- Z accuracy, %;

c) For *Offset (Bias) search:*

- test current;
- Z accuracy, %;

d) For *eccentricity* search:

- test current;
- Z accuracy, %;

e) For *Z(φ)* characteristic:

- test current;
- Z accuracy, %:
- φ_{INI};
- φ_{FIN};
- $\Delta\varphi$.

Moreover, there are *additional conditions* to determine *Z(φ)*.

1) Point search technique:

- Division by two;
- Step-by-step approximation - detection of each sequent point starts from Z_{PREV} value retrieved at previous angle and multiplied by 1.2, i.e $Z_{START} = Z_{PREV}*1.2$

2) *If no-operation search next point* area

- *From the* last *found point* - In case of protection non-operation at current angle, start the detection at all consequent angles from Z value, retrieved at last angle the protection operated;
- *From zero* - In case of protection non-operation at current angle start the detection with $\Delta\varphi$ set step at Z = 0.

3) *Mark ratios* area:

- Set values: K1 and K2. In case of protection non-operation, start point detection at constant impedance module $Z=Z_{SET}*K1$ (and later $Z=Z_{SET}*K2$) and angle change with $\Delta\varphi$ step.

4) *Refinement at the knee-point* area:

- If the angle difference module $|\varphi1- \varphi2|$ between two lines connecting three last points is more than 10°, start point searching by $\Delta\varphi/10$ step, (Figure 3.8.8).

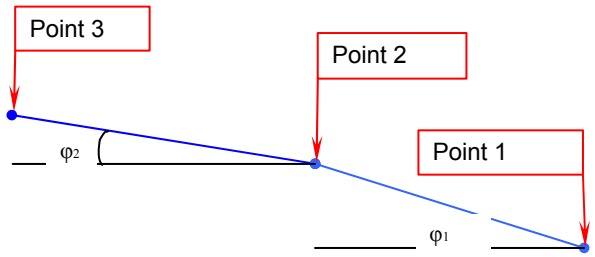


Figure 3.8.8 – Points search technique for impedance relay characteristic

f) For precision operating current I_{ACCUR}:

- Z accuracy;
- I_{INI} (initial current);
- I_{FIN} (final current);
- ΔI (current step);
- Z ratio (Z_{RES}).

Start the test - from I_{INI}. At each step Z_{OP} is obtained, than the current reduces by current step ΔI. Testing continues until Z becomes lower than $Z_{SET}.* Z_{RES.}$ Then a jump to the previous current occurs, current step reduces by 10 and more precise I_{ACCUR} current (at which $Z_{OP} > Z_{SET}.* Z_{RES}$) search starts.

Moreover, for each zone fault types to testing can be selected. However, if in the program main window the faults are selected the same (flag *identical* in field *Faults for all zones* is selected), fault type selection flags on the stage tabs become non-editable.

For each zone it is necessary to set individual test time, select RETOM-51 binary input number and relay contact type.

Settings and test parameters for all zones could be set also by pressing *Settings and test condition* button of settings and test parameters adjustment window. Figure 3.8.9 shows the appearing window.

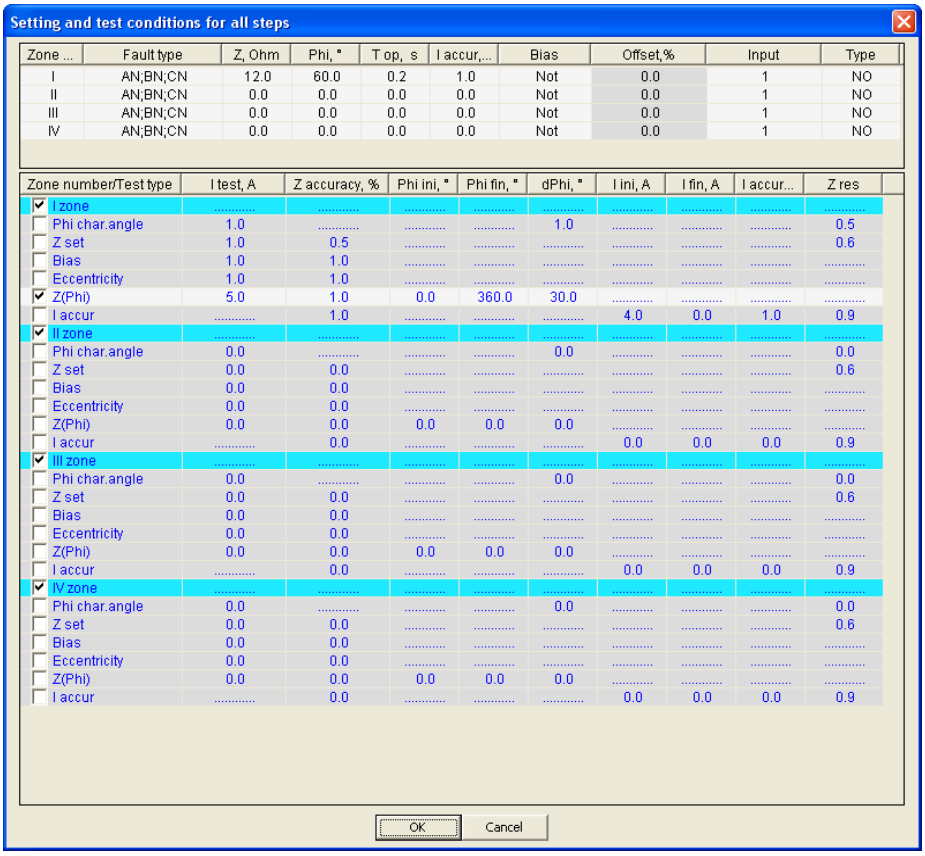

Setting and test conditions for all steps
Zone ... | Fault type | Z, Ohm | Phi, ° | T op, s | I accur,... | Bias | Offset,% | Input | Type
I | AN;BN;CN | 12.0 | 60.0 | 0.2 | 1.0 | Not | 0.0 | 1 | NO
II | AN;BN;CN | 0.0 | 0.0 | 0.0 | 0.0 | Not | 0.0 | 1 | NO
III | AN;BN;CN | 0.0 | 0.0 | 0.0 | 0.0 | Not | 0.0 | 1 | NO
IV | AN;BN;CN | 0.0 | 0.0 | 0.0 | 0.0 | Not | 0.0 | 1 | NO
Zone number/Test type | I test, A | Z accuracy, % | Phi ini, ° | Phi fin, ° | dPhi, ° | I ini, A | I fin, A | I accur... | Z res
I zone
Phi char.angle 1.0 1.0 0.5
Z set 1.0 0.5 0.6
Bias 1.0 1.0
Eccentricity 1.0 1.0
Z(Phi) 5.0 1.0 0.0 360.0 30.0
I accur 1.0 4.0 0.0 1.0 0.9
II zone
Phi char.angle 0.0 0.0 0.0
Z set 0.0 0.0 0.6
Bias 0.0 0.0
Eccentricity 0.0 0.0
Z(Phi) 0.0 0.0 0.0 0.0 0.0
I accur 0.0 0.0 0.0 0.9
III zone
Phi char.angle 0.0 0.0 0.0
Z set 0.0 0.0 0.6
Bias 0.0 0.0
Eccentricity 0.0 0.0
Z(Phi) 0.0 0.0 0.0 0.0 0.0
I accur 0.0 0.0 0.0 0.9
IV zone
Phi char.angle 0.0 0.0 0.0
Z set 0.0 0.0 0.6
Bias 0.0 0.0
Eccentricity 0.0 0.0
Z(Phi) 0.0 0.0 0.0 0.0 0.0
I accur 0.0 0.0 0.0 0.9
OK
Cancel

Figure 3.8.9 – *Settings and test parameters for all zones* window

Complex tests adjustment

Complex tests adjustment is performed by pressing the *Complex* tab of the settings and test parameters adjustment window (Figure 3.8.10).

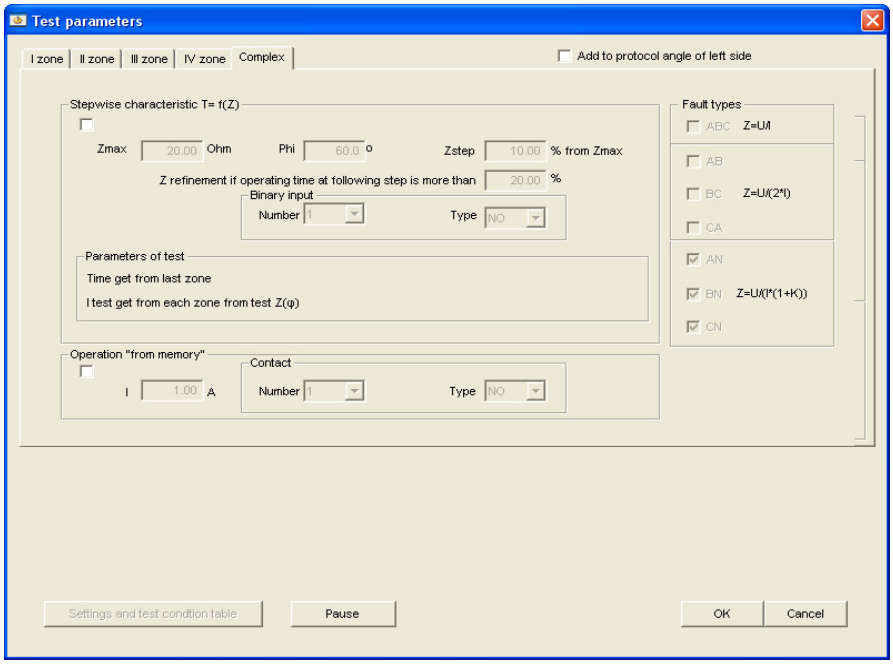


Figure 3.8.10 – Complex tests adjustment

Flags for complex tests are selected here and required test parameters are specified:

1) Stepwise characteristic T =f (Z):

This characteristic is taken for set of fault types also selected from this tab. Operating time of each stage Z is obtained at current set earlier for Z(φ)-characteristic for each stage. Time values for test ($T_{NO-LOAD}$, T_{FAULT}, T_{PAUSE}) are equal to those of the last used stage.

2) Operation from memory:

Three-phase close fault in the tripping area is simulated. Operating time and time of the selected contact closed state are recorded.

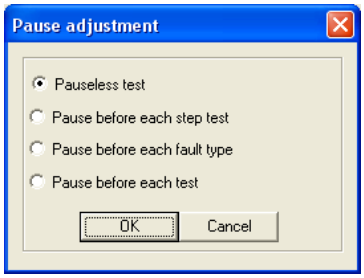
After test conditions are set, go back to the main program window and press *Start* button to start tests.

The test starts from the first zone marked by *Zone test* flag.

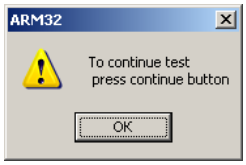
First it is necessary to select fault types for active zone and then selected tests are carried out.

During tests the Status bar shows type of the active test name. Current values of Z, φ and I are displayed in the fields.

The program is provided with a possibility to set pauses automatically. In the *Test adjustment* window press <*Pauses*> button and select necessary pause mode in the opening window:



If one of the tests with pauses is selected the program stops test automatically, and prompt window opens:

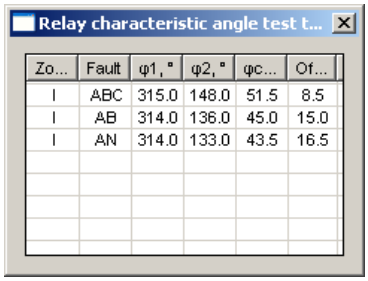


3.8.6 Test Results

Test results are represented in the main window both in graphic and table forms. To view the results tables press "*Tables*" button of the main window.

This button is active only if test results are available.

When pressing this button test results appear in tabular forms. Two of these tables are given in Figure 3.8.11.



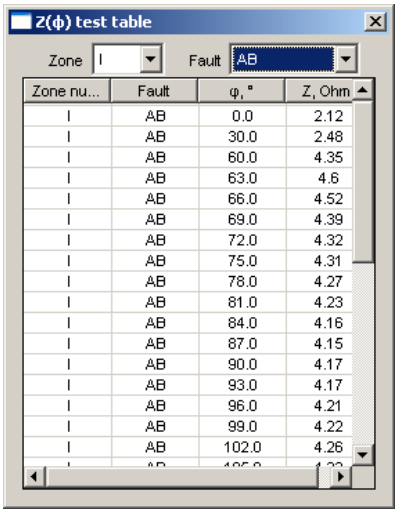


Figure 3.8.11 – Test table

During test the icon at table head of the active test is red.

Some tables in the upper part of the window have lists representing corresponding data (e.g. zone under test, fault type).

Test results tables can be closed independently by pressing button locating in the upper right corner. To close all the tables push again <*Tables*> button.

3.8.7 Test Protocol

Test protocol window (Figure 3.8.12) is enabled by pressing "*Protocol*" button of the *Toolbar*.

Test protocol registers:

- protection type;
- zone number of distance protection;
- settings and test parameters for each zone;
- test results in graphic and table form.

Selected zones and test types in the protocol are displayed in red, non-selected are black.

The protocol contains all displayed graphics and tables.

The active protocol can be sent for printing by pressing the corresponding button on the toolbar or by selecting the corresponding menu item. The detailed information about the protocol is described in «*Automatic Current Relay Test*» and «*Automatic Frequency Relay Test*» sections.

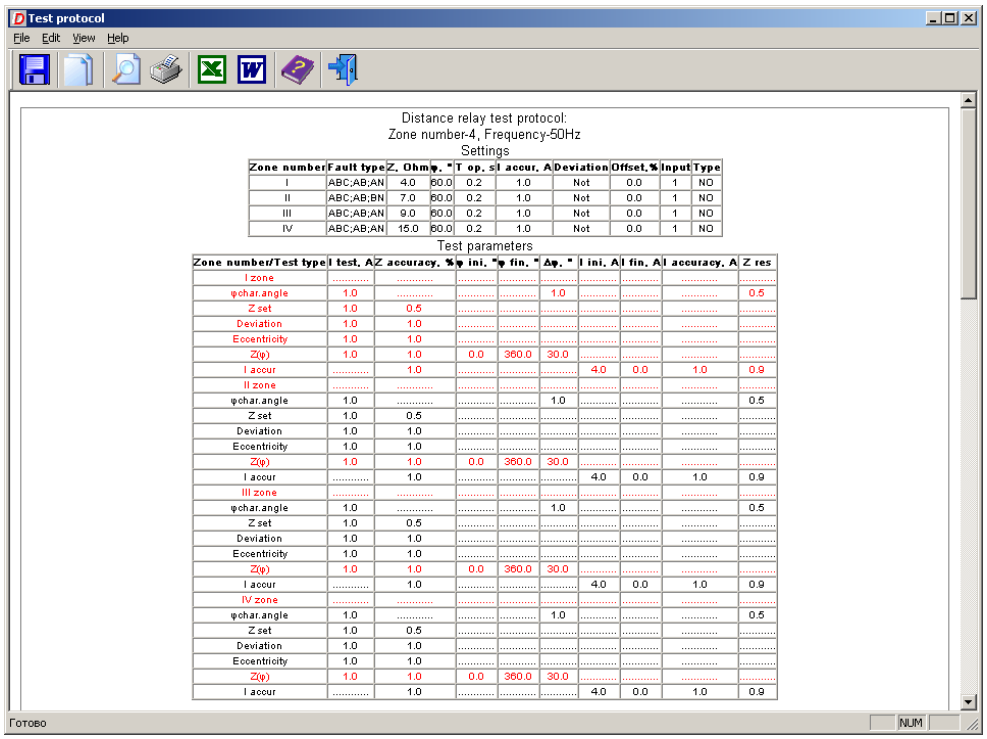


Figure 3.8.12 – Test protocol

3.9 Time Lag Meter

3.9.1 Application

The program allows to measure:
- operating time;
- reset time;
- time of two contacts closing diversity;
- time of two contacts opening diversity;
- contact closed/open state duration;
- bounce time.

3.9.2 Program Start

To start the program the *Time Lag Meter* icon ( ) in RETOM-51 program main window is used. After program start the main window will be displayed (see Figure 3.9.1).

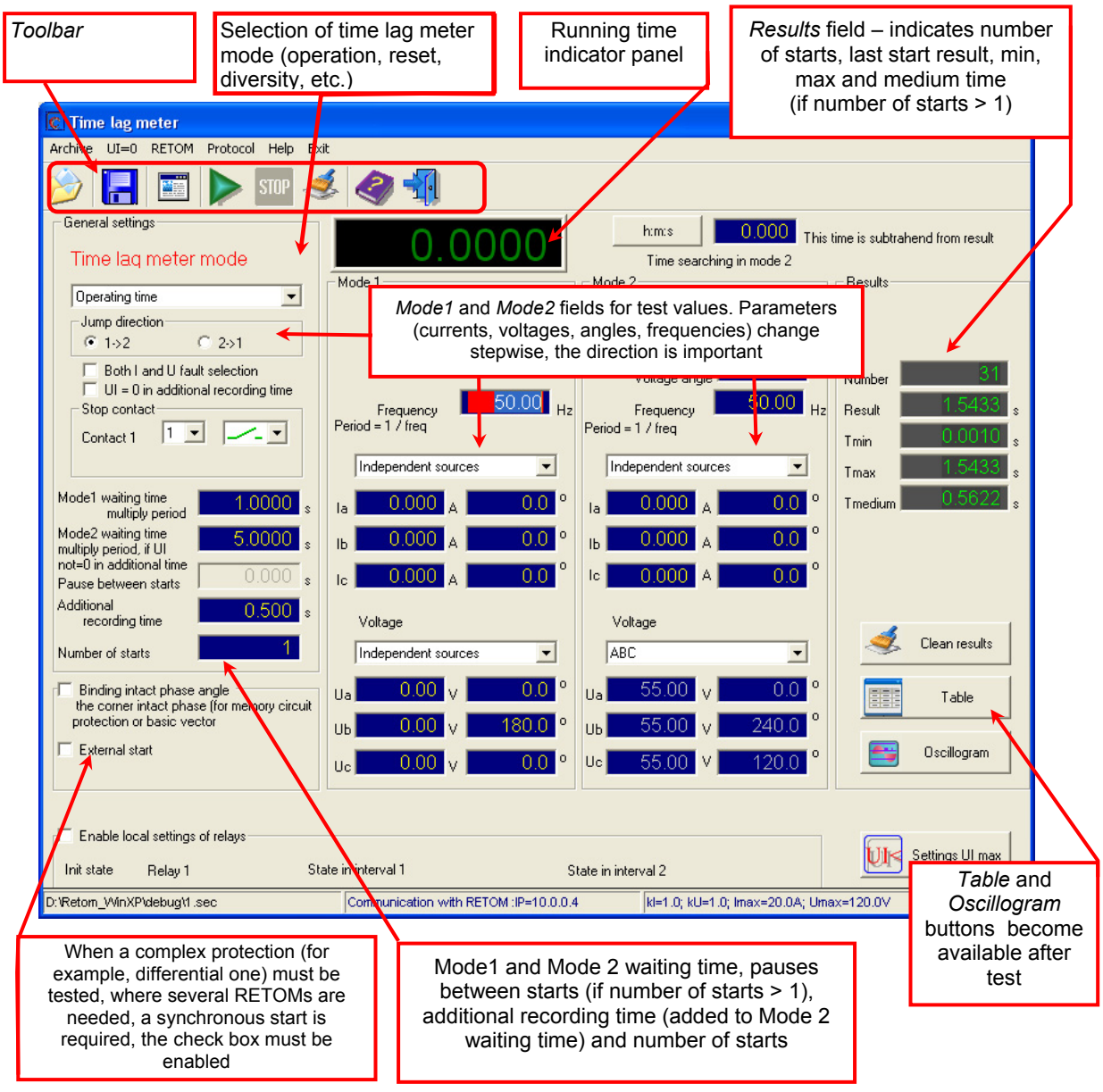
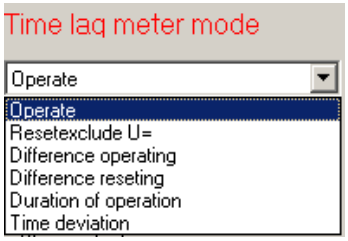

Toolbar
Selection of time lag meter mode (operation, reset, diversity, etc.)
Running time indicator panel
Results field – indicates number of starts, last start result, min, max and medium time (if number of starts > 1)
Mode1 and *Mode2* fields for test values. Parameters (currents, voltages, angles, frequencies) change stepwise, the direction is important
When a complex protection (for example, differential one) must be tested, where several RETOMs are needed, a synchronous start is required, the check box must be enabled
Mode1 and Mode 2 waiting time, pauses between starts (if number of starts > 1), additional recording time (added to Mode 2 waiting time) and number of starts
Table and *Oscillogram* buttons become available after test
Time lag meter
Archive UI=0 RETOM Protocol Help Exit
STOP
General settings
Time lag meter mode
Operating time
Jump direction
1->2
2->1
Both I and U fault selection
UI = 0 in additional recording time
Stop contact
Contact 1
Mode1 waiting time multiply period
Mode2 waiting time multiply period, if UI not=0 in additional time
Pause between starts
Additional recording time
Number of starts
Binding intact phase angle the corner intact phase (for memory circuit protection or basic vector
External start
0.0000
h:m:s
This time is subtrahend from result
Time searching in mode 2
Mode 1
Mode 2
Results
Frequency
Period = 1 / freq
Independent sources
Voltage
ABC
Number
Result
Tmin
Tmax
Tmedium
Clean results
Table
Oscillogram
Enable local settings of relays
Init state
Relay 1
State in interval 1
State in interval 2
Settings UI max
D:\Retom_WinXP\debug\1.sec
Communication with RETOM :IP=10.0.0.4
ki=1.0; kU=1.0; Imax=20.0A; Umax=120.0V

Figure 3.9.1 - *Time lag meter* program *window*

3.9.3 How to Work with the Program

The parameter being measured is selected *General settings* area of the program window.



Operate time (reset, diversity and etc.) is recorded when going to fault conditions (usually *Mode2*. But *Mode1* is also possible – in this case *2->1* should be selected for *Jump direction*).

When *Time lag meter mode*, *Jump direction* and *Stop contact* have been selected selected, *Mode1* and *Mode2 waiting time* must be set. Furthermore, number of tests to be carried out is to be determined (in *Number of starts* field). When several tests are carried out, *Pause between starts* must be specified. For monitoring (if necessary) the other contacts' response after switching the main one, *Additional recording time* field is used. For this set time *Mode2 (Mode1) waiting time* length will be prolonged (i.e. fault currents and fault voltages delivery time will be restrained for this certain time period). Contacts positions can be viewed in window *Oscillogram* by pressing the < *Oscillogram* > button in the right lower corner of the window.

In the left lower corner of the window there is a check box *External start*. It should be checked if 2 or more RETOM-51 devices are used for test, i.e. if complex protection is tested for which more than 3 current sources (for example, for differential current protection - 6 or 9 current channels) or more than 3 voltage sources are required. In order to synchronize start of two or more RETOM-51 devices an external start is used (external toggle switch, button or output relay of that RETOM-51 that is considered to be master).

Assume that two protection semi-assemblies located at opposite line ends are tested. Enable the check box <*External start*>. Then auxiliary fields appear: RETOM-51 binary input number, contact type by which external start will be done. Contacts operation signals of the toggle switch (relay) are transferred to the other line end. If the binary input operation is to be delayed for the time of transient (e.g., when a command is sent from the opposite line end), then the time of *Mode1* (the time of the process start, if a jump is made from *Mode1* to *Mode2*) has to be extended for the period of transient time.

Current, voltage, angle and frequency values are specified in *Mode1* and *Mode2* fields (see Figure 3.8.2). Independent currents and voltages can be set in these fields or either fault type or single-phase AC/DC current (voltage) can be selected.

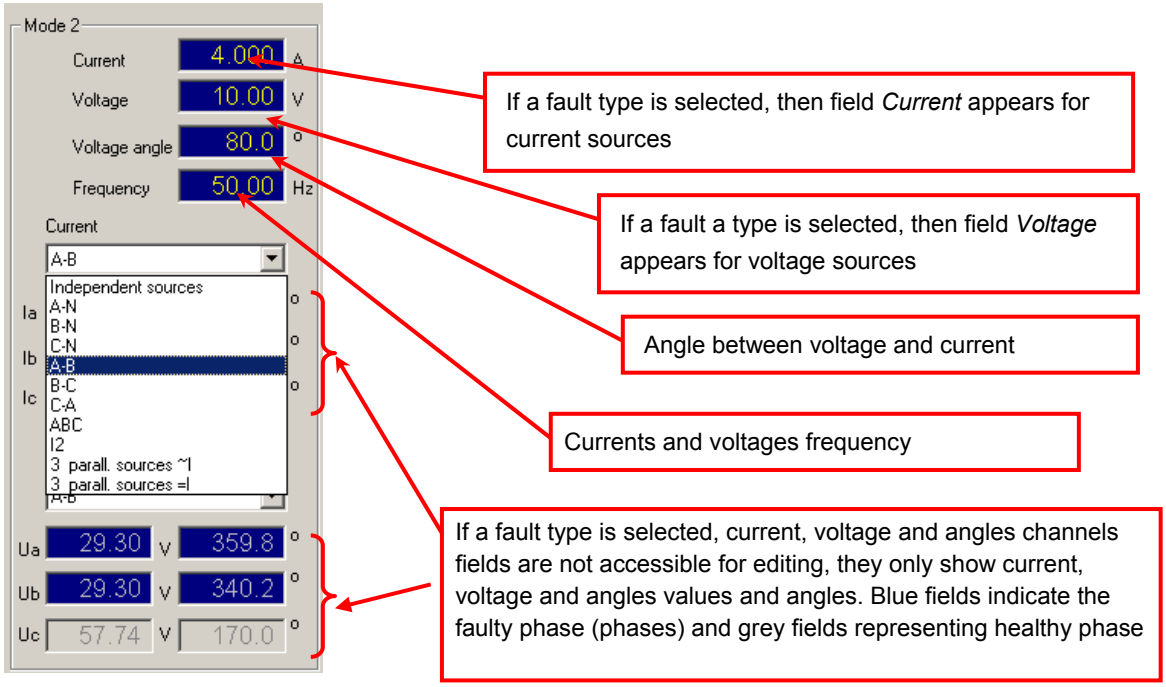


Figure 3.9.2 – Fields assignment in *Mode1* area

When time lag meter mode, *Mode1* and *Mode2* time, jump direction; *Stop contacts* and required current and voltage values in *Mode1* and *Mode2* have been selected, the test can be initiated. After test start currents and/or voltages will start delivering as well as time lag meter starts. The time will be displayed on the indicator panel:

The obtained time can be reduced by the value specified in the field:

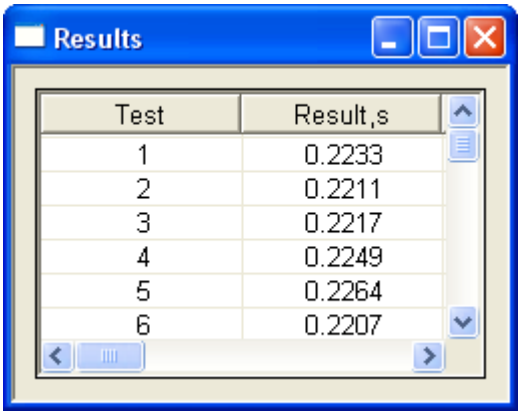
that defines the objective component (e.g., operation time of 4th relay contact).

After contact switching the time lag meter stops and the measured time is entered into the *Results* area:

This area is at the upper right corner of the program window and contains the following fields:

- *Number* – number of accomplished starts;
- *Result* – field with the last test result;
- T_{min}, T_{max}, T_{medium} are the fields with minimum, maximum and average times by which operate time spread (reset, closed condition, etc.) can be determined, if there was a number of starts.

After carrying out tests the results can be viewed by pressing the <*Table*> button in the right lower corner of the program window:



3.9.4 Test Protocol

Test results registered in a protocol (Figure 3.9.3) can be displayed by pressing the *Protocol* button ( ) of the *Toolbar.*

The detailed information about the protocol is described in «Automatic current relay test" and "Automatic frequency relay test" sections.

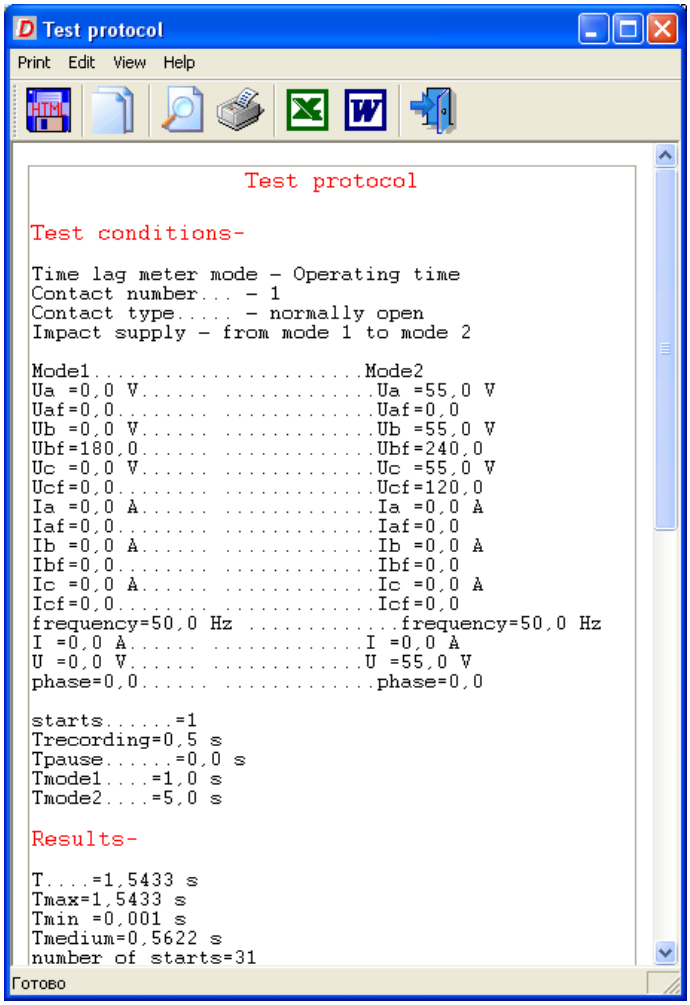


Figure 3.9.3 – Test protocol of the *Time lag meter* program

3.9.5 Test Oscillogram

A test oscillogram can be viewed by pressing the <*Oscillogram*> button in the right lower corner of the program window (see Figure 3.9.1). The oscillogram window is shown in Figure 3.9.4.

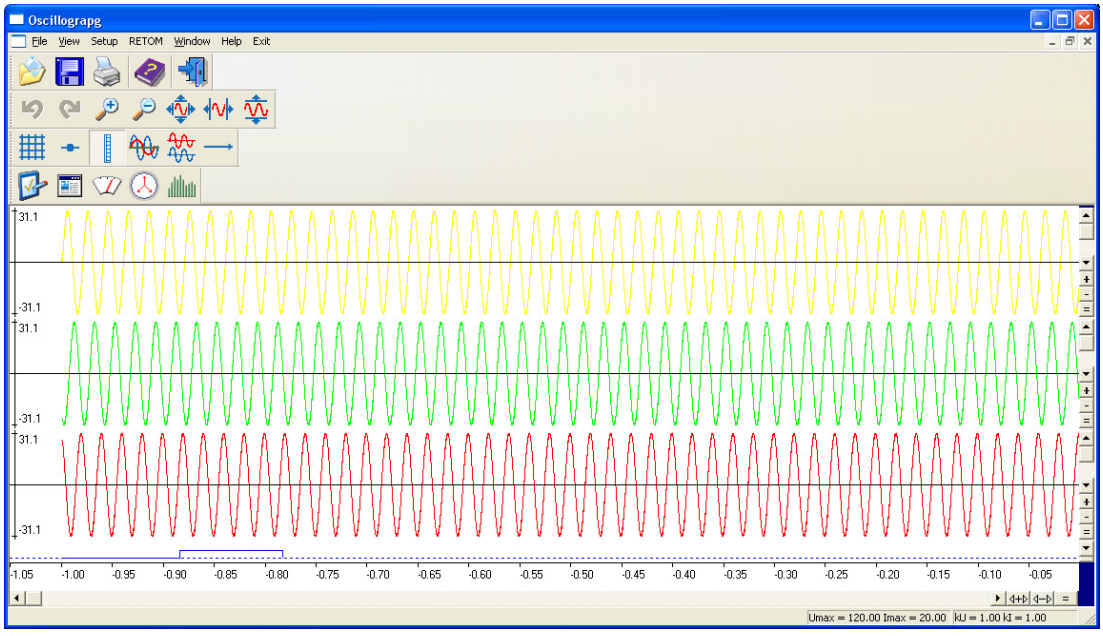


Figure 3.9.4 – *Oscillogram* window

Oscillogram handling is described in "*Simulation of the fault process recorded in COMTRADE-format*" and "*Definition of arbitrary shaped signals as the sum of harmonics"* sections.

3.10 Simulation of Fault Process Recorded in COMTRADE-format

3.10.1 Application

In many power systems various digital disturbance recorders (“Bresler-102(-103)”, BRI, “AURA”, TSRAP, “Parma”, etc.) are installed, which record analog and digital signals applied to them in case of fault conditions. Digital recording systems are also embedded into modern sophisticated relay protection and automation panels in order to hold the behavior of these devices during faults. All digital recorders register information in their own formats depending on design, repeat availability time, recorded information content, recording means, etc. For unification of formats manufacturers add COMTRADE-format data conversion utilities to digital recorders software.

This RETOM-51 program is intended for:

- simulation of any process recorded in COMTRADE format;
- input data scaling and time parameters setting during simulation;
- fixation of the tested device response to the applied action;
- comparison of under test device contacts operating time values with COMTRADE format recorded data;
- archiving operation results and print them out.

3.10.2 Program Start

To start the program the *comtrade* icon in RETOM-51 program main window is used.

3.10.3 How to Work with the Program

The main program window (Figure 3.10.1) consists of two parts, namely, list of signals saved in *COMTRADE* file (it is filled in after file opening), signals graphic presentation window.

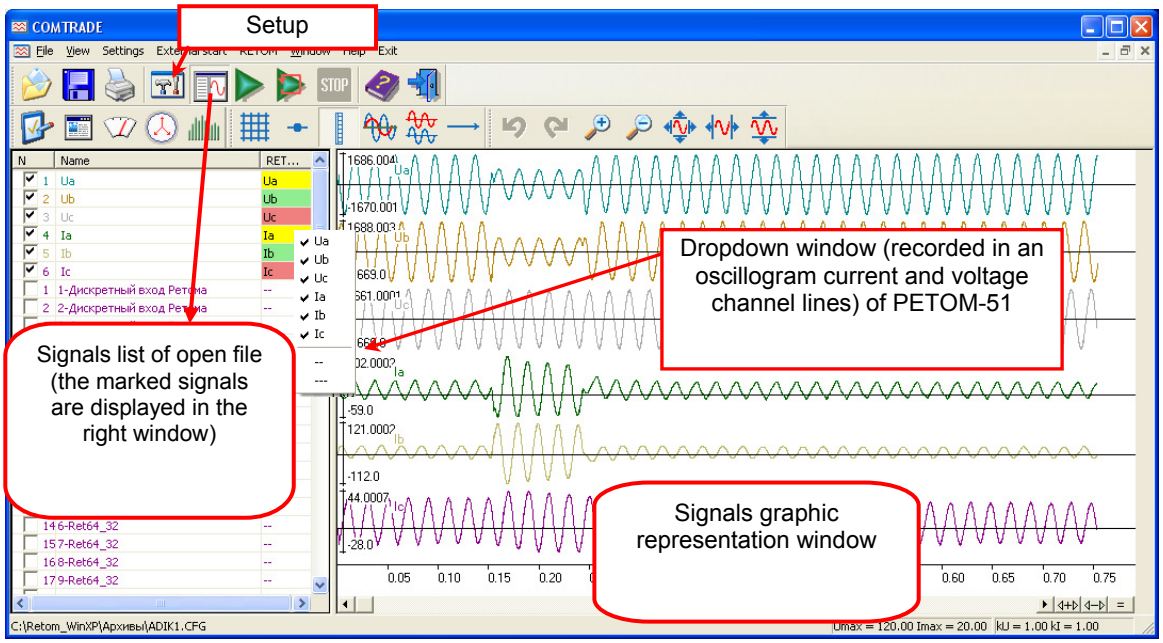

Setup
Dropdown window (recorded in an oscillogram current and voltage channel lines) of PETOM-51
Signals list of open file (the marked signals are displayed in the right window)
Signals graphic representation window

Figure 3.10.1 – Comtrade program main window and I and U channels setup window

To simulate a process by means of RETOM-51 you should assign signals correspondence to the device channels, set scale parameters and signal delivery time, press (*Start*) button and follow program instructions.

The information how to view and analyze signals is given in the “Sum of harmonics (definition of arbitrary shaped signals)”.

3.11 Sum of Harmonics (definition of arbitrary shaped signals)

3.11.1 Application

This program allows to synthesize signals (currents and voltages) and to deliver them to relay protection and automation device input. Each of signals is presented by five time spans. Over the first time span output signals constitute a symmetrical three-phase system of currents and voltages - here a prefault mode is simulated. In the rest four time spans each current and voltage signal is described by the sum of different sinusoid quantities. Each of them is represented by amplitude, frequency, phase, action time and the decay time constant. Practically, the user has an instrument which has six independently programmable current and voltage outputs.

For example, if we take two voltage sources, U_A and U_B, and program them in the following way – one to 50 Hz and 57.7 V, the other one to 49.5 Hz and 57.7 V, we will obtain signals for simulating, for instance, network and generator before breaker closing. In this way, relay of the type PH-55 and other timing mechanisms can be easily tested.

In order to analyze the apparatus behavior, for example, distance protection blocking during power swings, it is necessary to apply a signal set consisting of two sinusoid signals of equal amplitude but of different frequencies (frequency difference simulates the beat frequency) to current channels of tested distance protection.

As 5 time spans are provided for each signal, the program can simulate transition from one fault type to another one or automatic reclosing cycles – in order to test auto-reclosers (single-pole or three-pole).

Sum of harmonics program is an indispensable tool for testing relay protection and automation devices both at manufacturing and during operation because it allows to set signals within the frequency band of 0 … 500 Hz with accuracy better than 1% and with damping factor within -100 up to +100.

The program is intended for composite waveform generation. Signals of every RETOM-51 channel can be programmed independently by the formula:

$$a(t) = \sum_{n=1}^{10} \sqrt{2}\left(A_n \pm t\frac{\Delta A_n}{\Delta t} \right) \sin\left(2\pi\left(f_n \pm t\frac{\Delta f_n}{\Delta t} \right) + \varphi_n \right) e^{-k_n t}, \qquad (3.2)$$

где:
a(t) – current or voltage channel output signal;
A_n – output signal n-component effective value;
$\Delta A_n/\Delta t$ – n-signal effective value rate of change;
f_n – n-signal frequency;
$\Delta f_n/\Delta t$ – n- signal frequency rate of change;
φ_n – n-signal initial phase angle (given in radians);
t – current time value;
K_n – damping factor.

The program enables to:
- generate composite waveform signals;
- apply generated signals to the tested device;
- fix the tested device response to action applied;
- archive test results.

3.11.2 Program Start

To start the program the *Sum of harmonics* icon in RETOM-51 program main window is used.
After program start the main window will be displayed (see Figure 3.11.1).

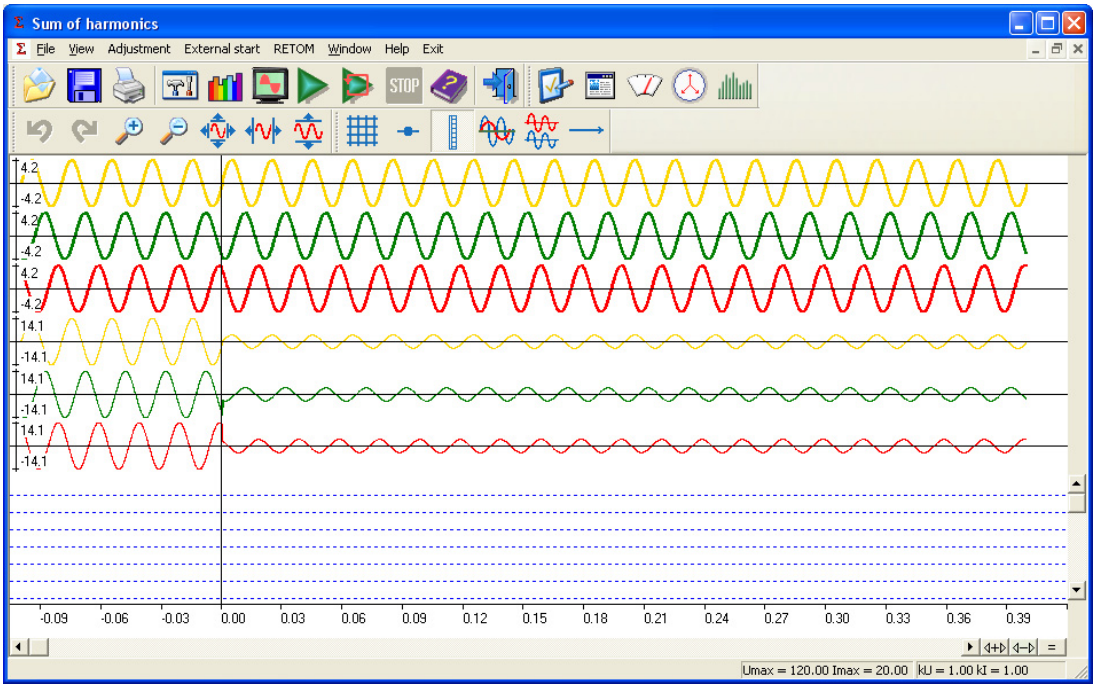
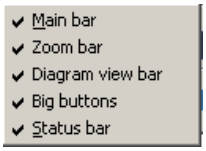

Sum of harmonics
File View Adjustment External start RETOM Window Help Exit
STOP
4.2
-4.2
14.1
-14.1
-0.09 -0.06 -0.03 0.00 0.03 0.06 0.09 0.12 0.15 0.18 0.21 0.24 0.27 0.30 0.33 0.36 0.39
Umax = 120.00 Imax = 20.00 kU = 1.00 kI = 1.00

Figure 3.11.1 – *Sum of harmonics* main window

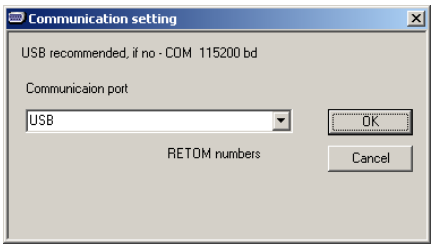
3.11.3 How to Work with the Program

In the upper part of the program (see Figure 3.11.1) there is a Menu bar consisting of the following items:

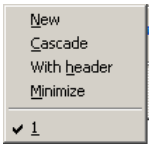
- *File* – allows archive handling (see "*Archive handling*");
- *View* – allows changing the window view: add/remove toolbar buttons; call scale bar, graph mode bar; change the button size in the window; show the status bar:



- *Adjustment* – this menu item is duplicated with *Toolbar* button. By pressing these buttons it's possible to setup general settings, i.e. previous mode parameters, issue time and procedure for each time span (the way of working with them is shown in figure 3.11.2);
- *External start* – to synchronize the start of two and more RETOM-51;
- *RETOM* – allows to select PC port type for RETOM connection;



- *Window* – allows to changes the fault interval oscillogram appearance;



- *Help* – calls *Help service*;
- *Exit* - exits the Program.

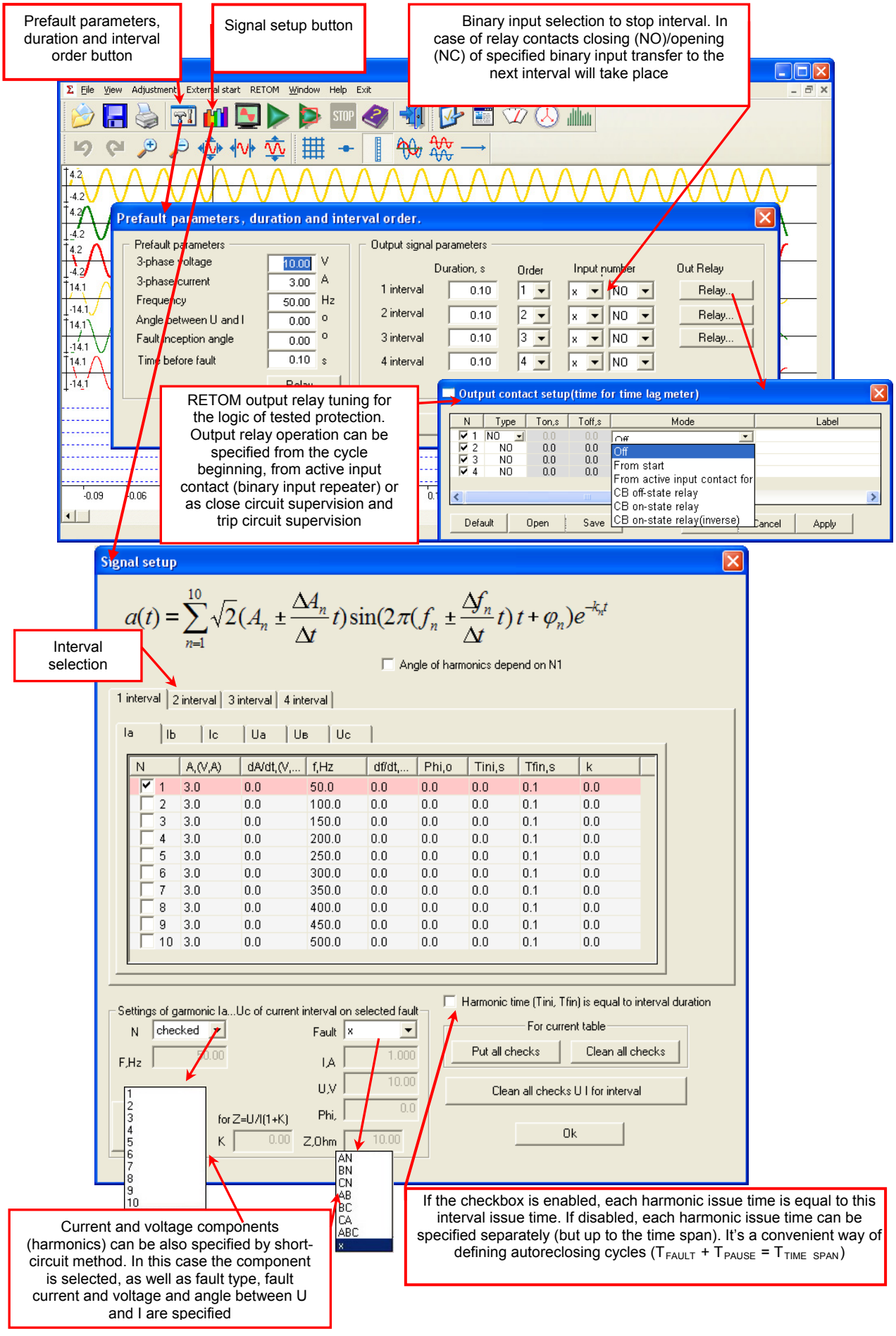

Prefault parameters, duration and interval order button
Signal setup button
Binary input selection to stop interval. In case of relay contacts closing (NO)/opening (NC) of specified binary input transfer to the next interval will take place
Prefault parameters, duration and interval order.
Prefault parameters
3-phase voltage 10.00 V
3-phase current 3.00 A
Frequency 50.00 Hz
Angle between U and I 0.00 o
Fault inception angle 0.00 o
Time before fault 0.10 s
Output signal parameters
Duration, s
Order
Input number
Out Relay
1 interval 0.10
2 interval 0.10
3 interval 0.10
4 interval 0.10
Relay...
RETOM output relay tuning for the logic of tested protection. Output relay operation can be specified from the cycle beginning, from active input contact (binary input repeater) or as close circuit supervision and trip circuit supervision
Output contact setup(time for time lag meter)
N Type Ton,s Toff,s Mode Label
Off
From start
From active input contact for
CB off-state relay
CB on-state relay
CB on-state relay(inverse)
Default Open Save Cancel Apply
Signal setup
$a(t)=\sum_{n=1}^{10}\sqrt{2}(A_n \pm \frac{\Delta A_n}{\Delta t}t)\sin(2\pi(f_n \pm \frac{\Delta f_n}{\Delta t}t)t+\varphi_n)e^{-k_n t}$
Interval selection
Angle of harmonics depend on N1
1 interval 2 interval 3 interval 4 interval
Ia Ib Ic Ua Uв Uc
N A,(V,A) dA/dt,(V,... f,Hz df/dt,... Phi,o Tini,s Tfin,s k
Harmonic time (Tini, Tfin) is equal to interval duration
Settings of garmonic Ia...Uc of current interval on selected fault
N checked
Fault x
F,Hz 50.00
I,A 1.000
U,V 10.00
Phi, 0.0
for Z=U/I(1+K)
K 0.00
Z,Ohm 10.00
For current table
Put all checks
Clean all checks
Clean all checks U I for interval
Ok
AN BN CN AB BC CA ABC x
Current and voltage components (harmonics) can be also specified by short-circuit method. In this case the component is selected, as well as fault type, fault current and voltage and angle between U and I are specified
If the checkbox is enabled, each harmonic issue time is equal to this interval issue time. If disabled, each harmonic issue time can be specified separately (but up to the time span). It's a convenient way of defining autoreclosing cycles (T_{FAULT} + T_{PAUSE} = $T_{TIME\ SPAN}$)

Figure 3.11.2 – Graphic signal presentation window and setup panel

In the graphic signal presentation window (Figure 3.11.3) it is possible to:
- change the signal scale;
- calculate signal rms values;
- calculate signal frequency content;
- display signal vector diagram;
- view the table of signal amplitude values;
- view quantitative characteristics (number of recorded values, min and max signal amplitudes).

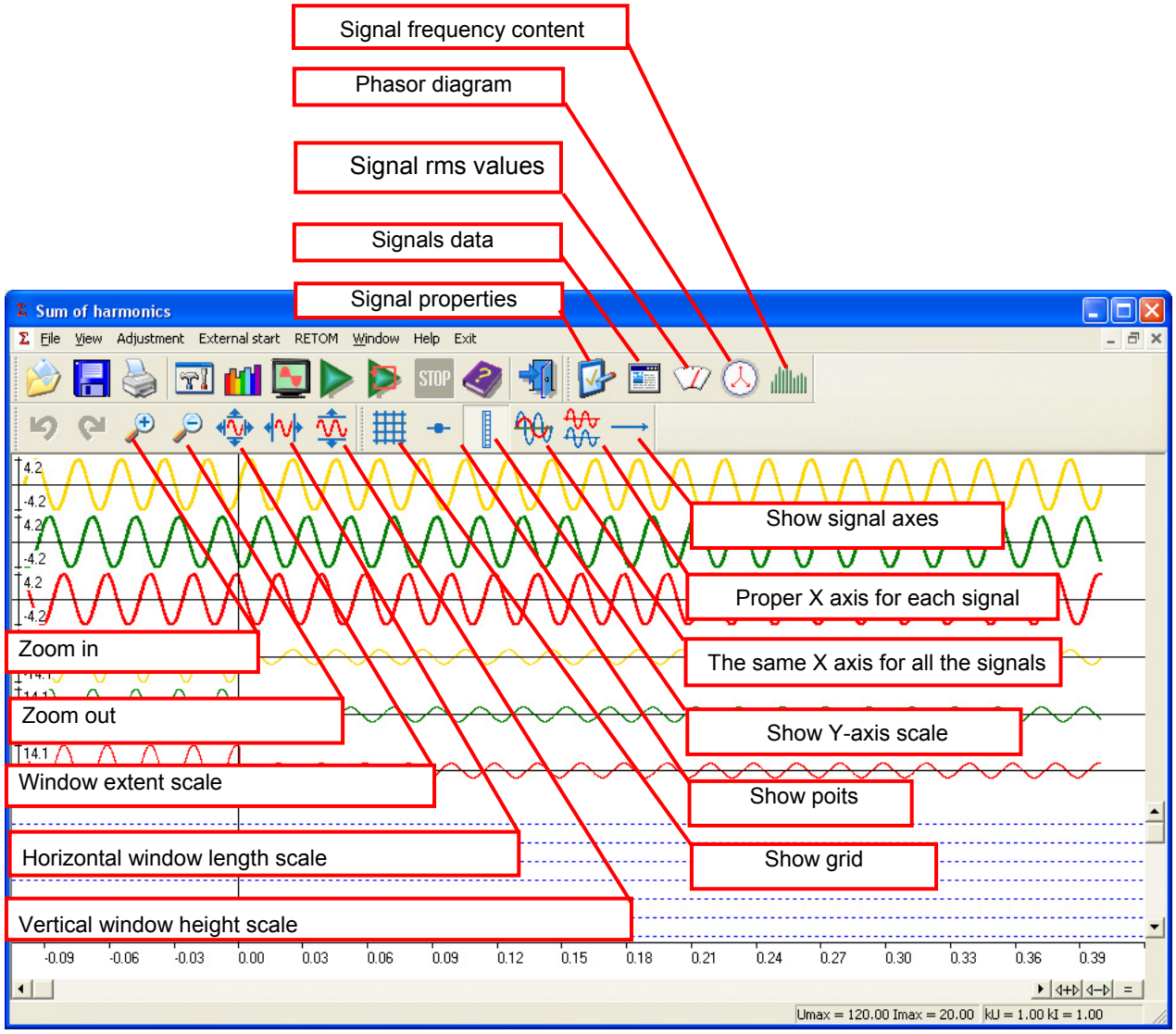

Signal frequency content
Phasor diagram
Signal rms values
Signals data
Signal properties
Sum of harmonics
File View Adjustment External start RETOM Window Help Exit
STOP
Show signal axes
Proper X axis for each signal
The same X axis for all the signals
Show Y-axis scale
Show poits
Show grid
Zoom in
Zoom out
Window extent scale
Horizontal window length scale
Vertical window height scale
-0.09 -0.06 -0.03 0.00 0.03 0.06 0.09 0.12 0.15 0.18 0.21 0.24 0.27 0.30 0.33 0.36 0.39
Umax = 120.00 Imax = 20.00 kU = 1.00 kI = 1.00

Figure 3.11.3 – Function of graphic signal presentation window elements

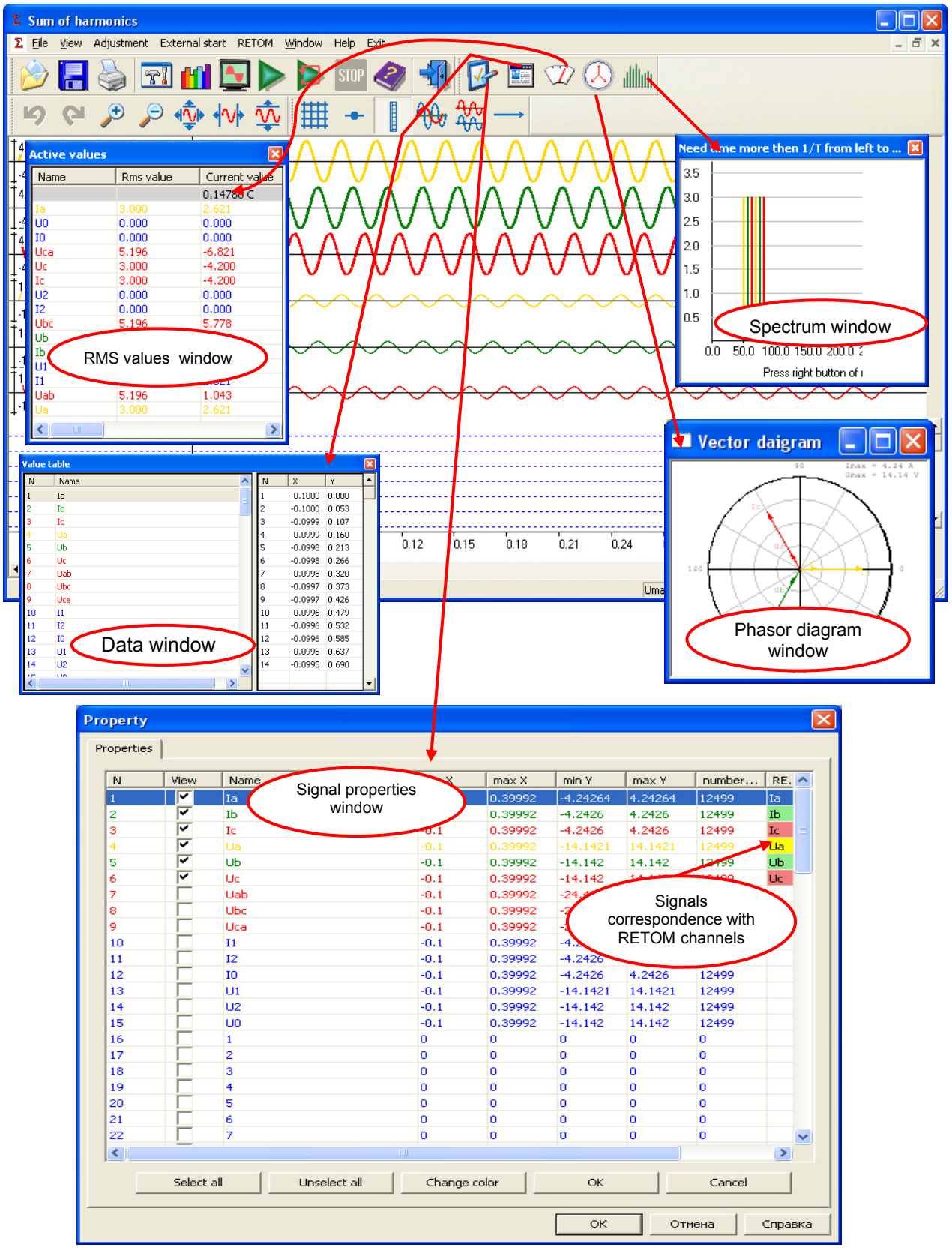


Figure 3.11.4 – Pop-up windows for signals analysis and their properties

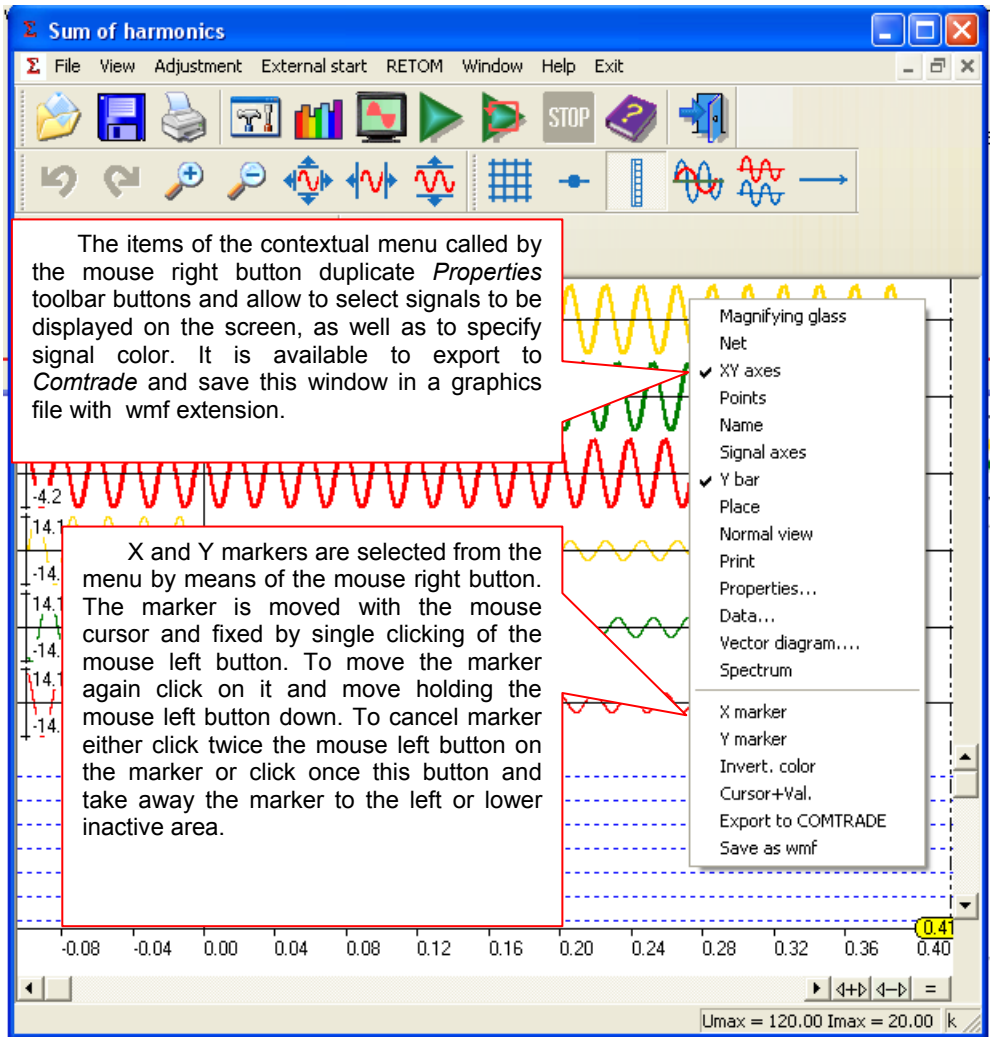

Sum of harmonics
File View Adjustment External start RETOM Window Help Exit
STOP
The items of the contextual menu called by the mouse right button duplicate *Properties* toolbar buttons and allow to select signals to be displayed on the screen, as well as to specify signal color. It is available to export to *Comtrade* and save this window in a graphics file with wmf extension.
X and Y markers are selected from the menu by means of the mouse right button. The marker is moved with the mouse cursor and fixed by single clicking of the mouse left button. To move the marker again click on it and move holding the mouse left button down. To cancel marker either click twice the mouse left button on the marker or click once this button and take away the marker to the left or lower inactive area.
Magnifying glass
Net
XY axes
Points
Name
Signal axes
Y bar
Place
Normal view
Print
Properties...
Data...
Vector diagram....
Spectrum
X marker
Y marker
Invert. color
Cursor+Val.
Export to COMTRADE
Save as wmf
-0.08 -0.04 0.00 0.04 0.08 0.12 0.16 0.20 0.24 0.28 0.32 0.36 0.40
0.41
Umax = 120.00 Imax = 20.00 k

Figure 3.11.5 – Function of oscillogram contextual menu elements

3.12 Power System RL-model

3.12.1 Application

The program is intended for testing relay protection devices by physical simulation of faults in user power systems by means of mathematical fault calculations with the help of RETOM-51. The fault conditions are close to real and consider transients in power systems. Using the program it's possible to define different fault types presetting basic parameters of the power system, prefault load, arc resistance at fault location, frequency variation in a power system. The program simulates four types of the protected line:

- single line;
- tapped line, a fault on a tap;
- double-circuit line, a fault on a parallel line;
- double-circuit line, a fault on a protected line.

Some types of faults, asynchronous conditions and power swings, open phase (without fault), load jump can be selected as the rated conditions. Calculation and test results are displayed as an oscillogram of signals and states of protection outputs characterizing the protection response.

3.12.2 Program Start

To start the program the RL *Power system model* icon in RETOM-51 program main window is used. When starting the program its work window will appear (see Figure 3.12.1).

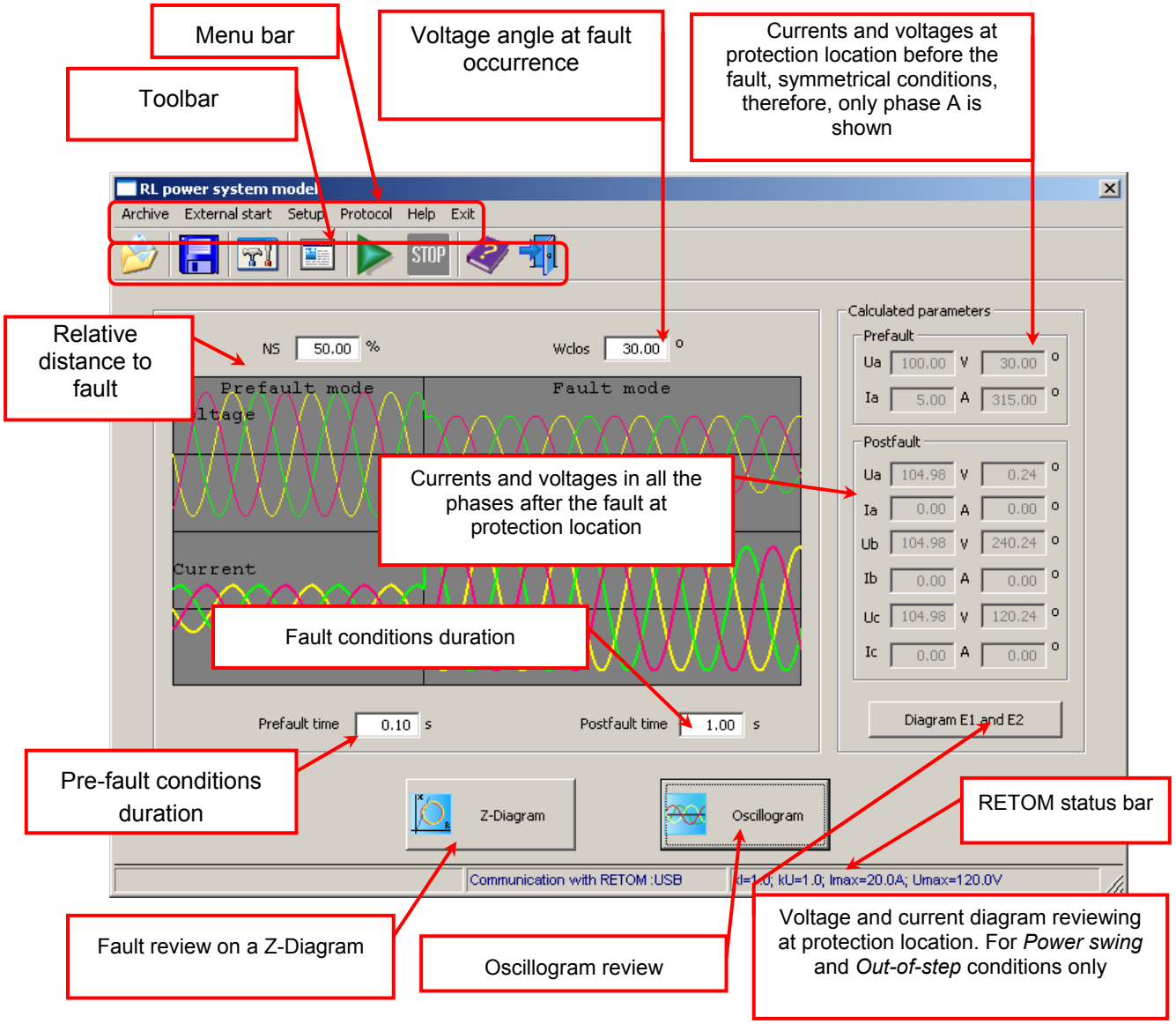


Figure 3.12.1 – *RL power system model* program window

3.12.3 How to Work with the Program

Similarly to the above-mentioned programs, the main items of the *Menu* bare are duplicated by *Toolbar* buttons (Figure 3.12.2).

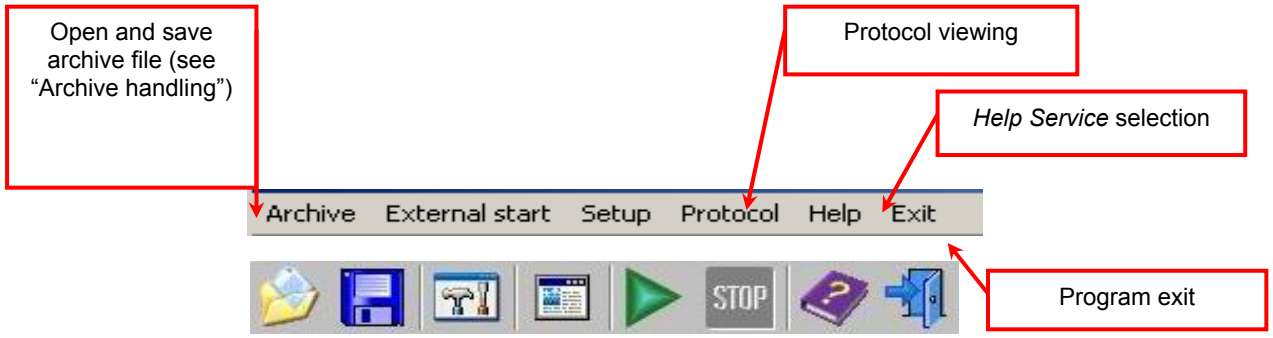


Figure 3.12.2 – *Menu* bar and *Toolbar* buttons

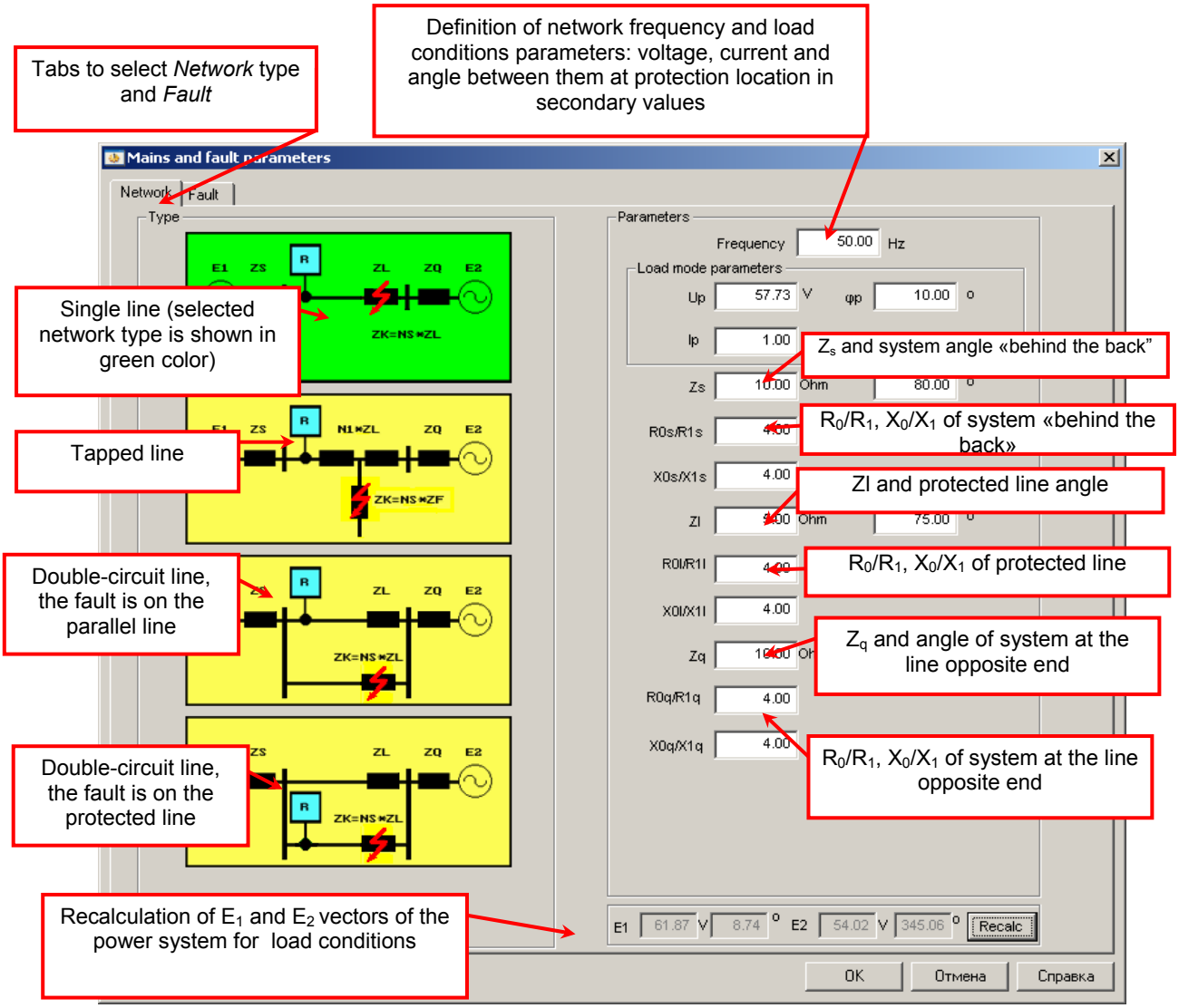


Figure 3.12.3 – Setup window

Power system parameters (I, U, Z) are specified in secondary values in setup window (see Figure 3.12.3). For double-circuit line network impedances of both parallel lines are considered to be equal.

For all *Network Types* the dead-end operating mode, both - 'dead end' in front (EMF *E2=0*) and dead-end "behind the back" can be specified.

When a tapped line is selected, tapping parameter fields are added to this window (see Figure 3.12.4).

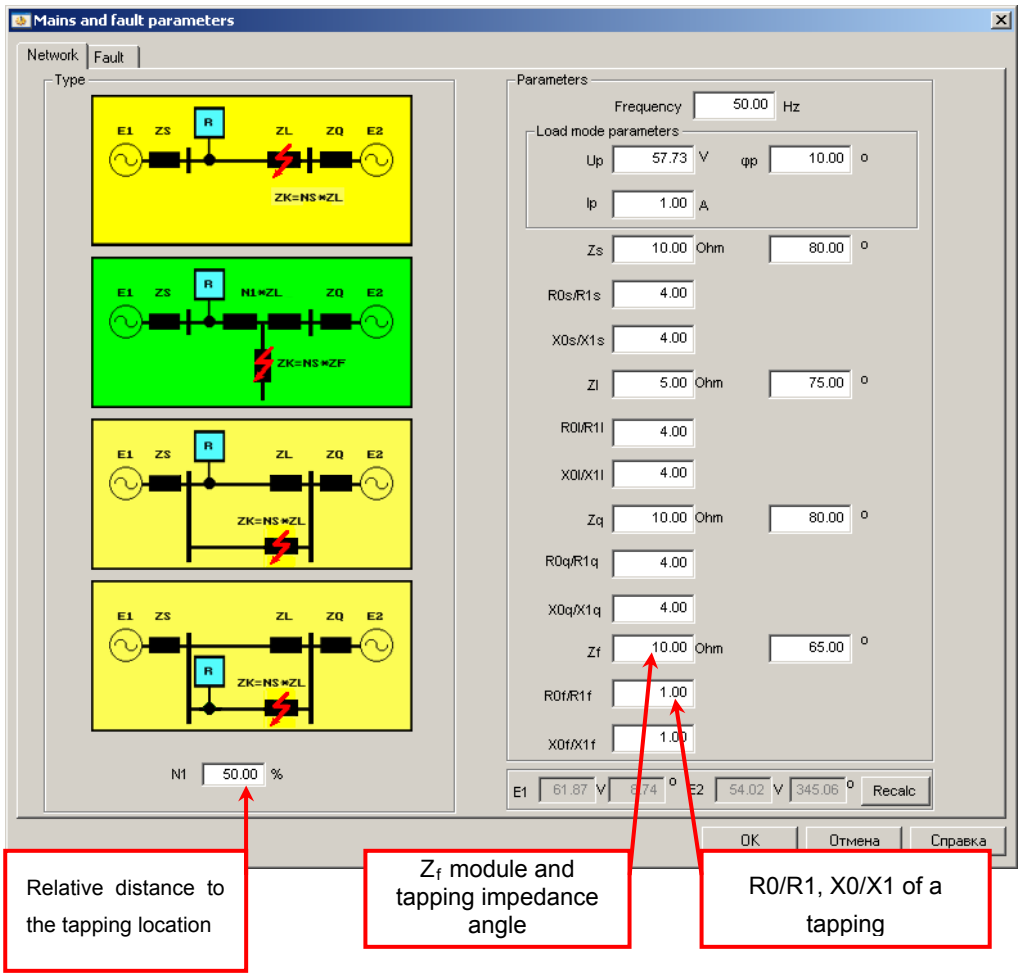


Figure 3.12.4 – Setup window for a tapped line

When network and load conditions parameters have been set, fault type should be specified (see Figure 3.12.5).

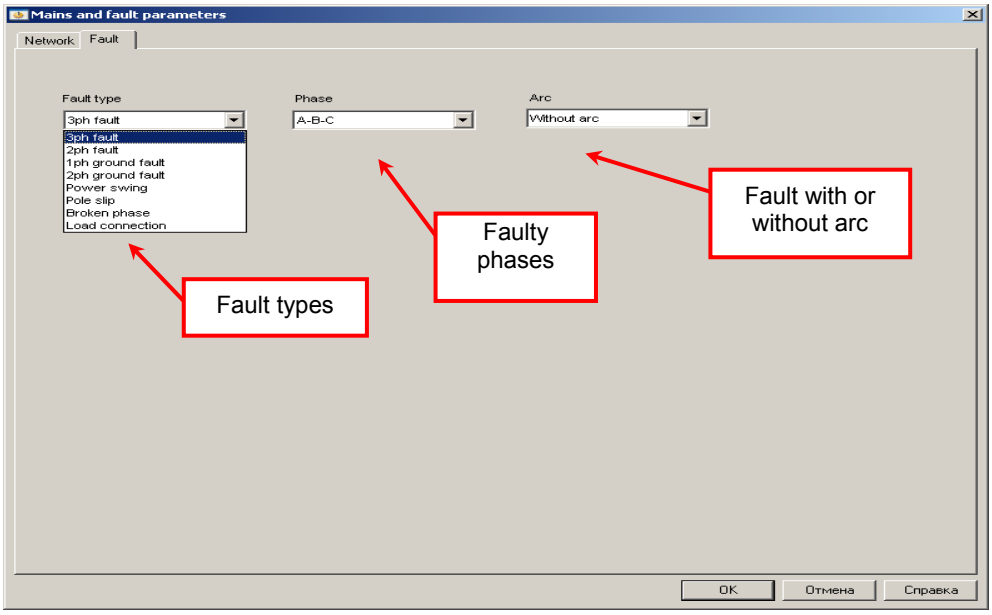
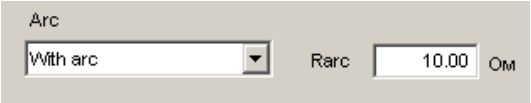


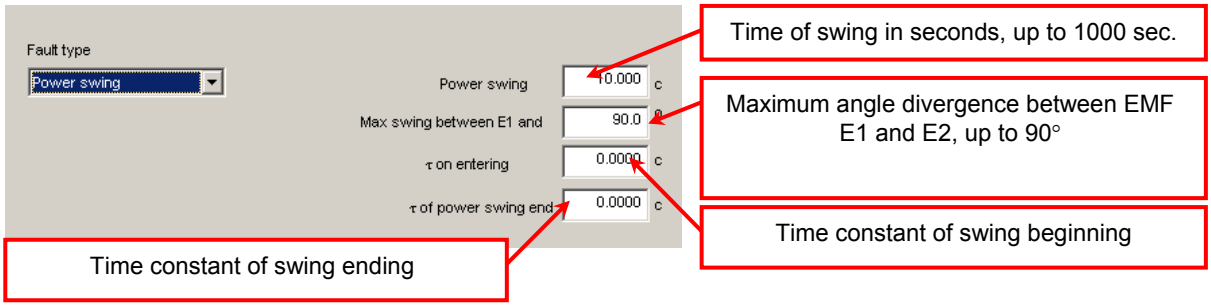
Figure 3.12.5 – Fault type selection

If a short circuit has been selected as a fault, it can be metallic (without arc) or arcing. When arcing fault is selected, an editable field R_{ARC} appears:



where R_{ARC} is an active resistance at fault location, its value is user-defined.

When *Power swing* is selected, the following fields appear:



Power swing is, actually, a symmetric mode and power swing current is calculated as follows:

$$I = \left(\left(E_1\angle\varphi_{E_1} - E_2\angle\left(\varphi_{E_2} + \delta(t)\right)\right)/\left(Z_S\angle\varphi_S + Z_L\angle\varphi_L + Z_Q\angle\varphi_Q\right)\right)\angle\arg\varphi_1, \quad (3.3)$$

where:

I, arg φ_I – phase current value and angle at protection location;

Z_S, φ_S, Z_L, φ_L, Z_Q, φ_Q – impedances and angles of „behind the back“ system, protected line and other line end system, respectively;

$\delta(t)$ - function determining power swings:

$$\delta(t) = (\max\varphi - \Delta\varphi)\left(1 - \exp\left(-\frac{t}{\tau_1}\right)\right)/2 + (\max\varphi - \Delta\varphi)\left(1 - \exp\left(-\frac{t}{\tau_1}\right)/2\right)Cos\left(2\pi\frac{t}{T_{КАЧ}}\right)\exp\left(-\frac{t}{\tau_2}\right), \quad (3.4)$$

where: maxφ - max E_1 and E_2 vectors divergence, specified in same named field;

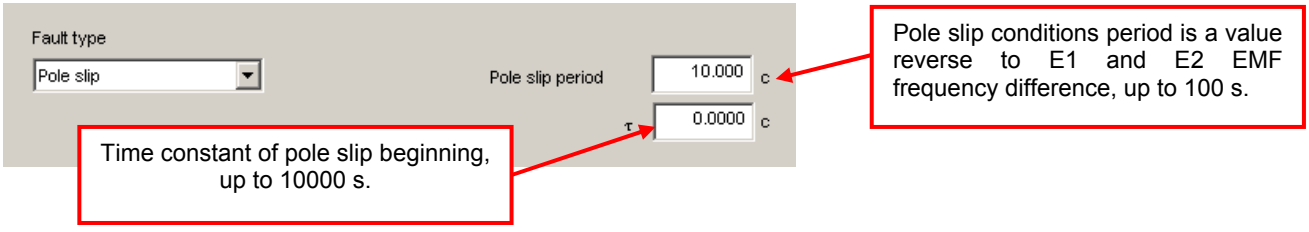
$\Delta\varphi = \varphi_{E2} - \varphi_{E1}$ – initial angle between E_2 and E_1 vecors;

τ_1 – τ on entering, specified in same named field;

τ_2 – τ of power swing end, specified in same named field;

T_{swing} – power swing period, specified in same named field.

When *Pole slip* is selected, the following fields appear:


Fault type
Pole slip
Pole slip period
10.000
c
τ
0.0000
c
Pole slip conditions period is a value reverse to E1 and E2 EMF frequency difference, up to 100 s.
Time constant of pole slip beginning, up to 10000 s.

Pole slip is a symmetrical mode, the current is calculated according to the formula:

$$I = \left(\left(E_1\angle\varphi_{E_1} - E_2\angle\left\{\varphi_{E_2} + 2\pi\left(t/T_{AX}\right)\left(1 - \exp\left(-t/\tau_{AX}\right)\right)\right\}\right)/\left(Z_S\angle\varphi_S + Z_L\angle\varphi_L + Z_Q\angle\varphi_Q\right)\right)\angle\arg\varphi_1, \quad (3.5)$$

where:

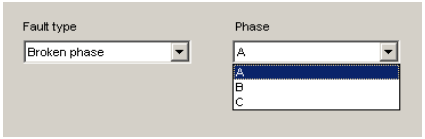
I, arg φ_I – one phase current value and angle at protection location;

Z_S, φ_S, Z_L, φ_L, Z_Q, φ_Q – impedances and angles of „behind the back“ system, protected line and other line end system, respectively;

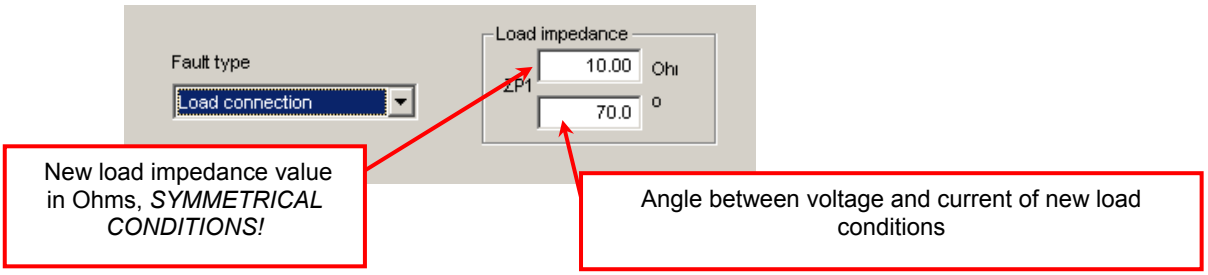
T_{AX} – pole slip period; specified in same named field;

τ_{AX} – τ of pole slip mode beginning, also specified by user.

When *Broken phase* is selected the following panel appears:



When the *Load connection* is selected the following panel appears:



When pressing *Z-diagram* button in the program main window the following window appears (see Figure 3.12.6.).

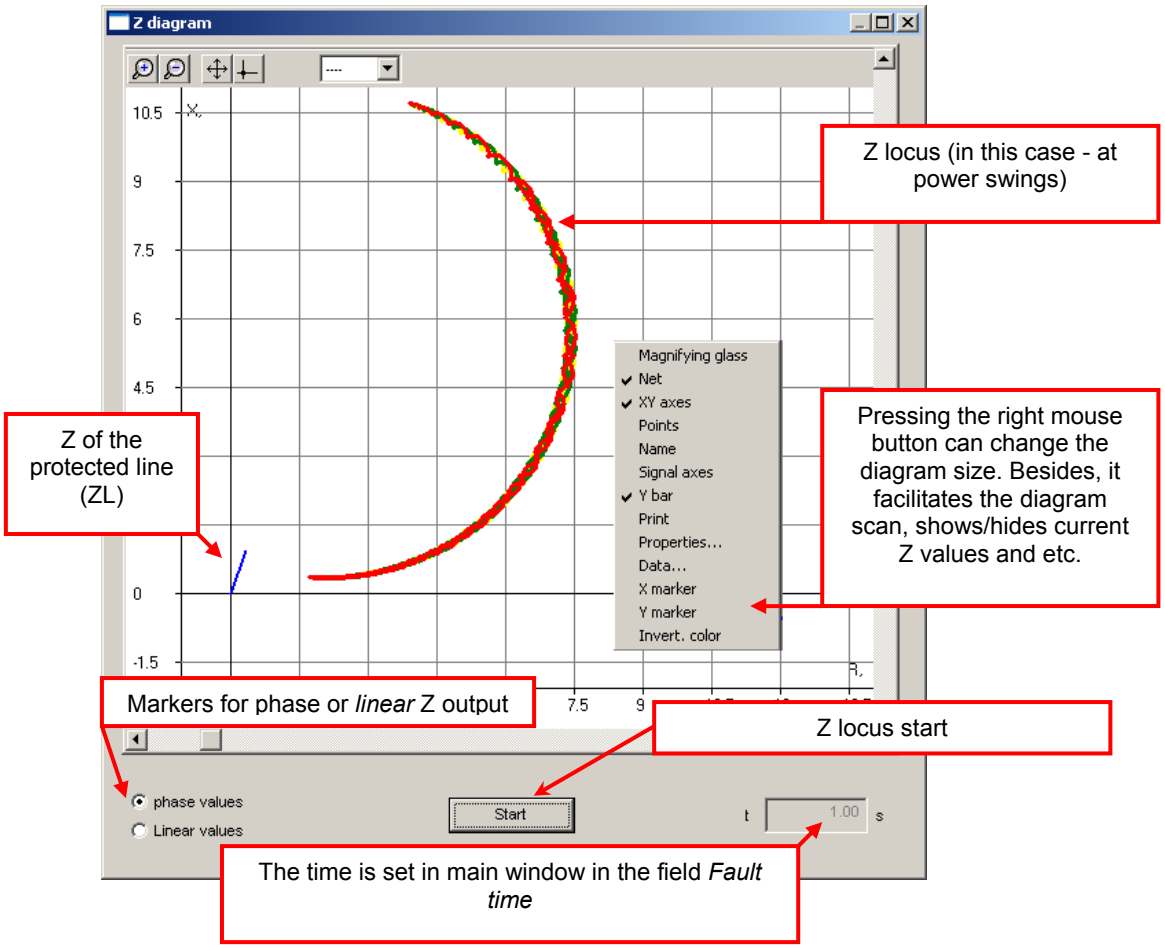


Figure 3.12.6 – *Z-diagram* window

Pressing the right mouse button in *Z-diagram* window results in opening of contextual menu by means of which the diagram type can be changed (show/hide the grid, X and Y axes, ruler, X and Y axes markers and etc.) or printout the diagram. Moreover, when selecting the *Properties* item the window appears (see Figure 3.12.7) allowing to change Z properties (color, required Z - phase or linear values).

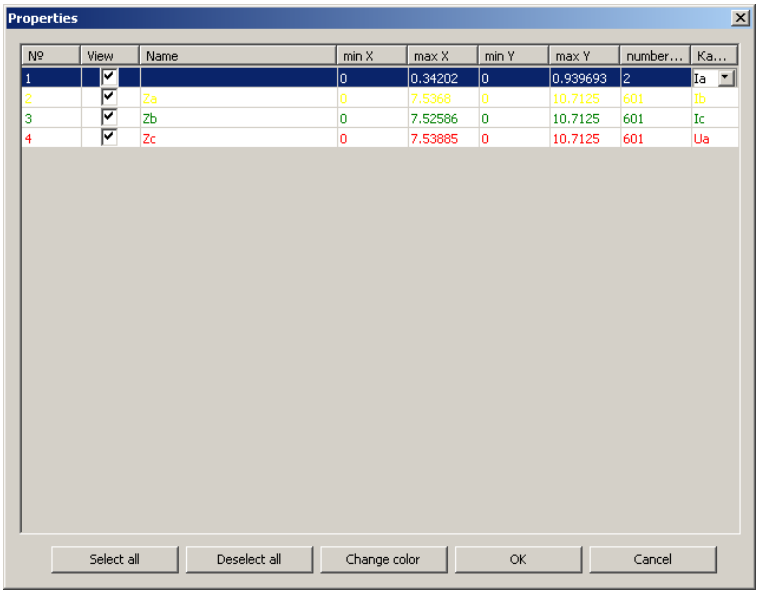


Figure 3.12.7 – *Properties* window

<*Data*…> item selection of this contextual menu shows Z values table (Figure 3.12.8).

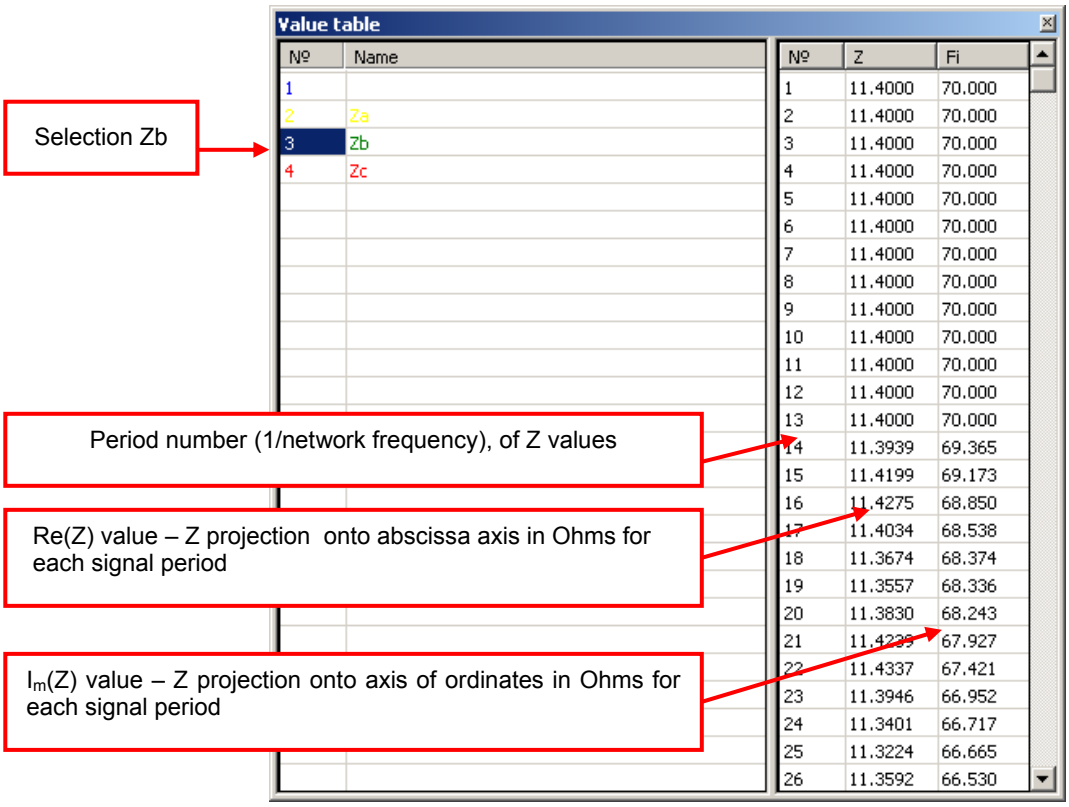


Figure 3.12.8 – Z values table

Pressing the *Oscillogram* button in the main window the oscillogram window (graphic signal presentation window – section 3.11) will be displayed.

If *Power swing* or *Pole slip* is selected as fault, the *Diagram E1 and E2* button appears in the program main window, under prefault and postfault current and voltage values fields.

Using the diagram we can monitor power swing or pole slip conditions with reference to vectors of one phase *E1, E2* and *Up, Ip* (voltage and current at protection location - Figure 3.12.9).

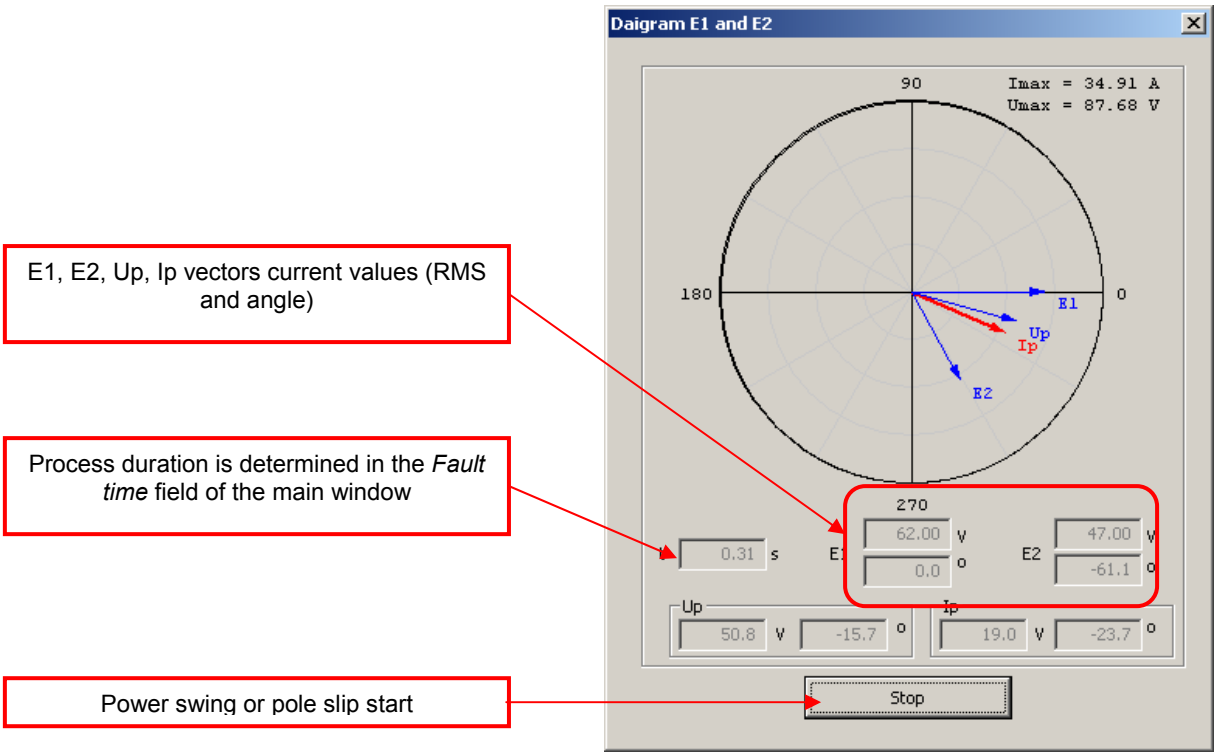


Figure 3.12.9 – Vector diagram for power swing display

3.12.4 Test Protocol

Pressing the *Protocol* button of the *Toolbar* the *Protocol* window will be displayed on the screen (see Figure 3.12.10).

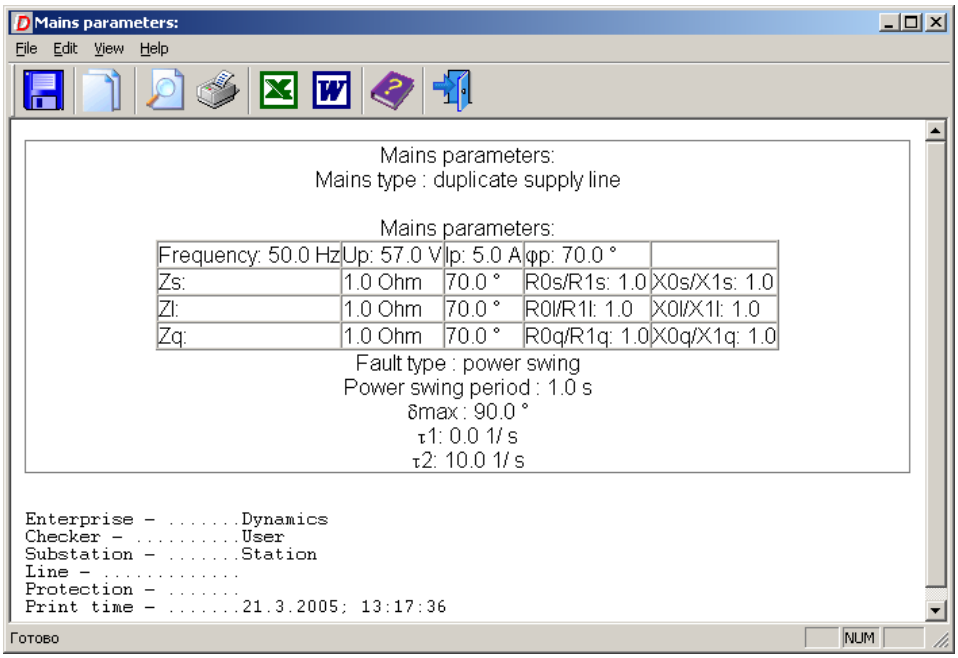

Mains parameters:
File Edit View Help
Mains parameters:
Mains type : duplicate supply line
Mains parameters:
Frequency: 50.0 Hz Up: 57.0 V Ip: 5.0 A φp: 70.0 °
Zs: 1.0 Ohm 70.0 ° R0s/R1s: 1.0 X0s/X1s: 1.0
Zl: 1.0 Ohm 70.0 ° R0l/R1l: 1.0 X0l/X1l: 1.0
Zq: 1.0 Ohm 70.0 ° R0q/R1q: 1.0 X0q/X1q: 1.0
Fault type : power swing
Power swing period : 1.0 s
δmax : 90.0 °
τ1: 0.0 1/ s
τ2: 10.0 1/ s
Enterprise – .....Dynamics
Checker – .....User
Substation – .....Station
Line – .....
Protection – .....
Print time – 21.3.2005; 13:17:36
Готово
NUM

Figure 3.12.10 – Protocol wondow

The *Protocol* of this program differs from test program protocols. This protocol only contains network parameters, fault type, options, archive file path and name. For more details about protocol handling, *Protocol Toolbar* buttons and *Menu* items refer to the *"Automatic current relay test", "Automatic frequency relay test"* sections.

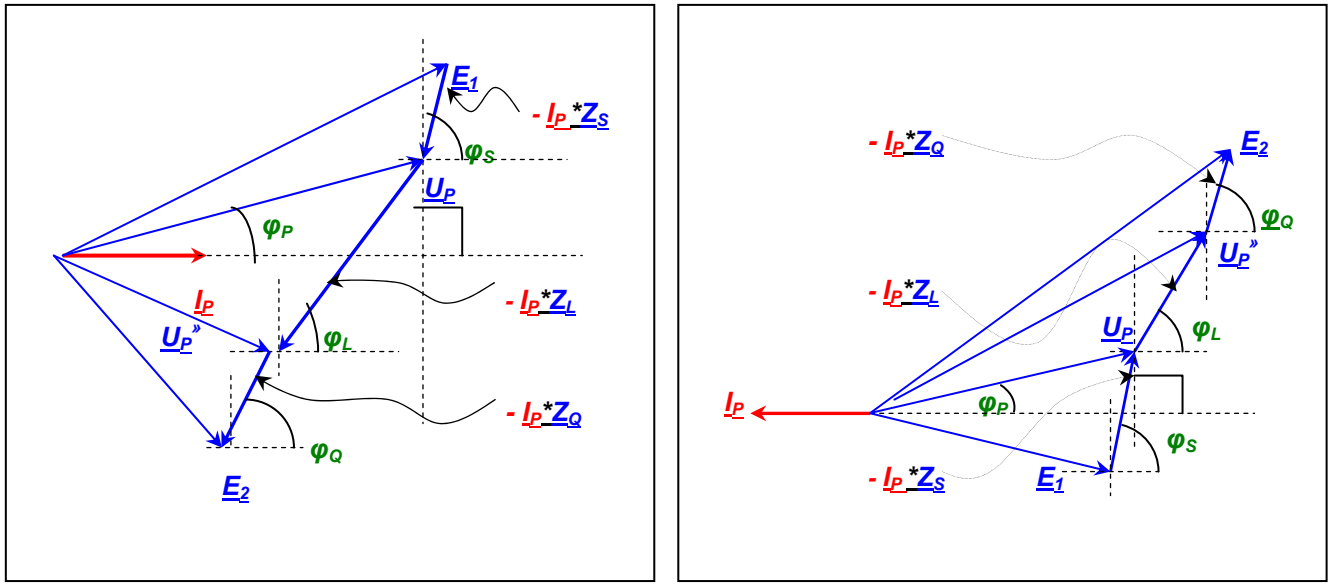
3.12.5 Recommendations on Setting some Network and Operation Modes

As this is a power system of RL-model , “behind the back” system impedance arguments Z_S, line impedance Z_{L1}, other end system impedance Z_Q cannot exceed 90°, i.e. argument φ_S, φ_L, φ_Q range is 0…+90°, i.e. only the resistive-inductive area.

Prefault argument (an angle between prefault U_p and I_p) can change within 0…360°, as four *Network Types* (with EMF $\underline{E}_1$ and $\underline{E}_2$ sources) enable to set a prefault mode with the power direction either to line or to buses.

How to define and calculate $\underline{E}_1$ and $\underline{E}_2$ vectors (their module and argument) is shown in Figure 3.12.11.

Load (prefault) voltage diagram for *Network Type No.1*, single line with two EMF, vectos: $\underline{U}_p$ – voltage at protection location; $\underline{U}_p''$ – other line end voltage; $\underline{E}_1$ and $\underline{E}_2$ – EMF1 and EMF2 source voltages applied to protection loaction; I_p – load current; φ_p – load argument (angle between load U_p and I_p); φ_S, φ_L, φ_Q - impedance arguments of “behind the back” system Z_S, line Z_L, other line end system Z_Q:



a) Bus to line power direction

b) Line to bus power direction

Figure 3.12.11 – Voltage diagram

For all four *Network Types* (single line, tapped line, double-circuit line (two parallel lines) with a fault on parallel line and double-circuit line with a fault on protected line) the dead-end operating mode can be set to both - dead-end in front (EMF E_2=0) and dead-end “behind the back” (EMF E_1=0).

Setting of dead-end operating mode:

To set the dead-end operating mode for *Network Type No.1 and 2* (single line and tapped line) so that the dead-end is in front, i.e. EMF $E_2 = 0$, the following condition should be provided: $\underline{Z}_p = \underline{Z}_L + \underline{Z}_Q$, i.e. vectors of Z_L line impedance and other end system impedance $\underline{Z}_Q$ equal to load vector $\underline{Z}_p = \underline{U}_p/\underline{I}_p$. Z_p is calculated as follows:

$$Z_P = \sqrt{(Z_L \sin\varphi_L + Z_Q \sin\varphi_q)^2 + (Z_L \cos\varphi_L + Z_Q \cos\varphi_q)^2}\,, \tag{3.6}$$

and load argument φ_p is calculated as follows:

$$\varphi_P = arctg(Z_L \sin\varphi_L + Z_Q \sin\varphi_q)/(Z_L \cos\varphi_L + Z_Q \cos\varphi_q). \tag{3.7}$$

Based on calculated Z_p the required load voltage is found $U_p = I_p Z_p$.

If U_p, I_p and φ_p are set (e.g. measured by volt ampere phase meter), i.e. load parameters are defined and Z_p and φ_p are known, then $\underline{Z}_Q$ is to be calculated following the condition $\underline{Z}_Q = \underline{Z}_p - \underline{Z}_L$. Z_Q is defined according to the formula:

$$Z_Q = \sqrt{(Z_L \sin(\varphi_L + 180°) + Z_P \sin\varphi_P)^2 + (Z_L \cos(\varphi_L + 180°) + Z_P \cos\varphi_P)^2}\,, \quad (3.8)$$

and argument φ_Q is calculated as follows:

$$\varphi_Q = arctg(Z_L \sin(\varphi_L + 180°) + Z_P \sin\varphi_P)/(Z_L \cos(\varphi_L + 180°) + Z_P \cos\varphi_P)\,. \quad (3.9)$$

As being mentioned earlier, the argument φ_Q setting range is 0 - 90°, i.e. it cannot be negative. If it is, then you should increase the load argument φ_p (make it more inductive), e.g. φ_p = 0 (as measured), set it to 5 - 10°.

To set the dead-end operating mode for *Network Type No.3 and 4* (double circuit line with a fault on parallel line and double circuit line with a fault on protected line) so that the dead-end is in front, i.e. EMF $E_2 = 0$, the following condition should be provided: $\underline{Z_p} = \underline{Z_L}/2 + \underline{Z_Q}$, i.e. half sum of vectors of $\underline{Z_L}$ line impedance and other end system impedance $\underline{Z_Q}$ equal to load vector $\underline{Z_p} = \underline{U_p}/\underline{I_p}$. $\underline{Z_p}$ is calculated as follows:

$$Z_P = \sqrt{(Z_L \sin\varphi_L / 2 + Z_Q \sin\varphi_q)^2 + (Z_L \cos\varphi_L / 2 + Z_Q \cos\varphi_q)^2}\,, \quad (3.10)$$

and load argument φ_p is calculated as follows:

$$\varphi_P = arctg(Z_L \sin\varphi_L / 2 + Z_Q \sin\varphi_q)/(Z_L \cos\varphi_L / 2 + Z_Q \cos\varphi_q)\,. \quad (3.11)$$

Similarly, if U_p, I_p and φ_p are set (e.g. measured by volt ampere phase meter), i.e. load parameters are defined and Z_p and φ_p are known, then $\underline{Z_Q}$ is to be calculated following the condition $\underline{Z_Q} = \underline{Z_p} - \underline{Z_L}/2$. Z_Q is defined according to the formulae:

$$Z_Q = \sqrt{(Z_L \sin(\varphi_L + 180°)/2 + Z_P \sin\varphi_P)^2 + (Z_L \cos(\varphi_L + 180°)/2 + Z_P \cos\varphi_P)^2}\,, \quad (3.12)$$

and argument φ_Q is calculated as follows:

$$\varphi_Q = arctg(Z_L \sin(\varphi_L + 180°)/2 + Z_P \sin\varphi_P)/(Z_L \cos(\varphi_L + 180°)/2 + Z_P \cos\varphi_P)\,. \quad (3.13)$$

So far, the argument φ_Q should be within the range 0 - 90°.

To set the dead-end operating mode for *Network Types No.1, 2, 3 and 4* so that the dead-end is “behind the back”, i.e. EMF $E_1 = 0$, the following condition should be provided: $\underline{Z_S} = \underline{Z_p}$, i.e. “behind the back” system impedance vector $\underline{Z_S}$ equals in module and opposite in direction to the load vector $\underline{Z_p} = \underline{U_p}/\underline{I_p}$. Correspondingly, module $Z_S = Z_p$, and argument $\varphi_p = \varphi_S + 180°$ or $\varphi_S = \varphi_p - 180°$, but “behind the back” system impedance argument φ_p can be within the range 0 - 90°, and so the load argument φ_p should be within 180 - 270°.

Thus, to set the dead-end operating mode for the network (*Types* 1,2,3 and 4), either with the dead-end in front or “behind the back”, is as easy as that and the only thing to observe is the above-mentioned restrictions. The button *Recalculate* is used to check that settings are correct and the obtained value E_1 (or E_2) = 0 (see Figure 3.12.12).

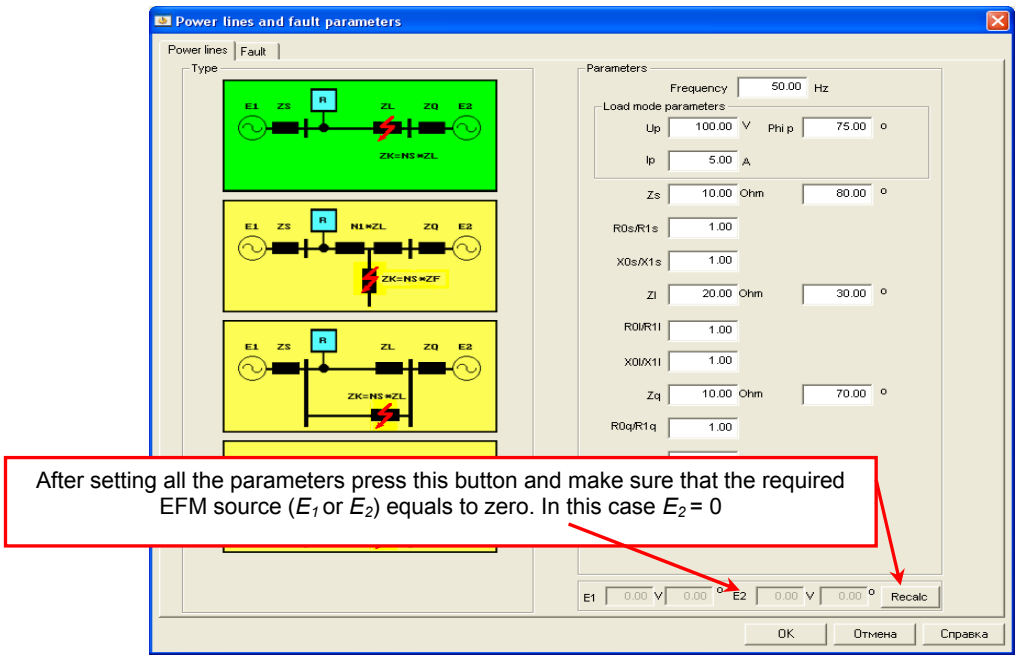


Figure 3.12.12 – *Recalculate* button of settings window

When *Power swings* mode is selected (for *Network* Type No.1), set $\tau_{\text{swing on entering}} = 0$ and $\tau_{\text{power swing end}} = 10\,000$ to make power swings begin immediately at max amplitude between EMF *E1* and *E2* and do not attenuate. Similarly, in *Pole slip* mode, to activate it immediately, set $\tau_{\text{pole slip begin}} = 0$.

3.13 Manual Control of Current Sources for Differential Protection test

3.13.1 Application

The program is intended for manual test of differential current protection of transformers, generators, etc. The program is a supplement to program “Independent current and voltage source manual control” and enables control of 2 or 3 RETOM-51 devices, i.e. 6 or 9 current sources.

3.13.2 Program Start

To start the program the *Manual control for differential protection* icon in RETOM-51 program main window is used.

Before program start the polling window appears (Figure 3.13.1).

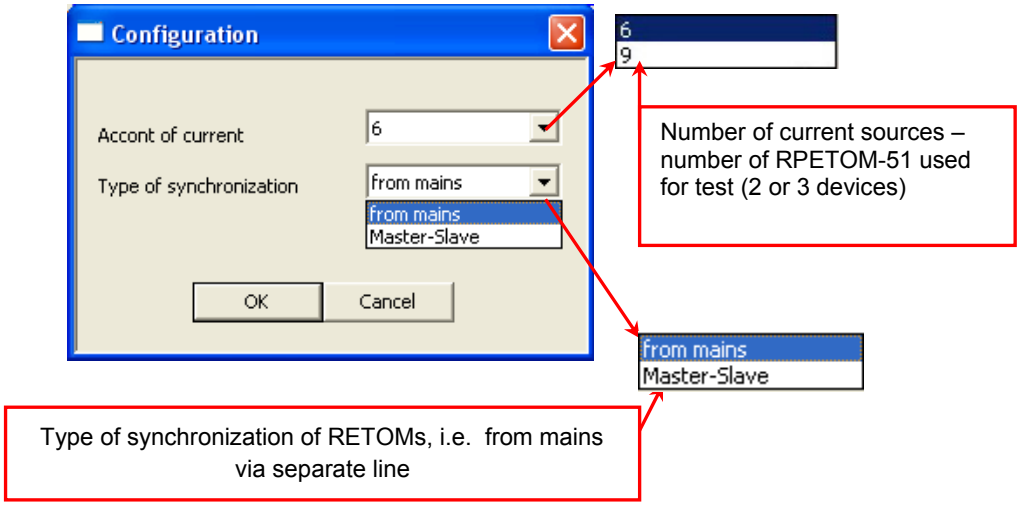


Figure 3.13.1 – Poll window

If 2 or 3 devices are synchronized from the mains, before the test starts it is necessary to check instrument phasing, i.e. all instruments have the same phase sinusoid at current I_A angle 0°. It would be better to use RETOM-51 *Oscillograph* – the one with the lower series number. The main window (with vector diagram, control instruments, etc.) is displayed on this device. After connection of I_A channel (by means of probes connected according to their polarity) of one RETOM-51 to analog input No.1 and I_A channel of other RETOM-51 to analog input No.2 and applying current to both channels (e.g., 5 A) check that signals are equal in phase (use ADC function, i.e. RETOM-51 oscillograph) (ADC button in right bottom corner of program main window). Please, see also details in program description “Independent current and voltage source manual control”. Current circuits should be already connected to load. If signals are “turned out” into 180°, close the program, exit RETOM program package, switch off RETOM-51 with higher series number and change polarity of mains cord plug. Similarly, if polarity of the third RETOM-51 is “turned out” (9 current sources are selected), do the same. When you test sophisticated microprocessor protections voltage induced by current (e.g., 5 A) can be insufficient for RETOM-51 oscillograph monitoring. Increase current up to 10-15 A.

If Master-Slave (i.e. selected line) synchronization is used, phasing will be correct based on the synchronization principle (Figure 3.13.2.). The correct connection of synchronization lines is important here. Connection is made through connectors of G12A1G_P12LFDO (input) and G12A2G_P12LFDO (output) type, located on the front panel of the device.

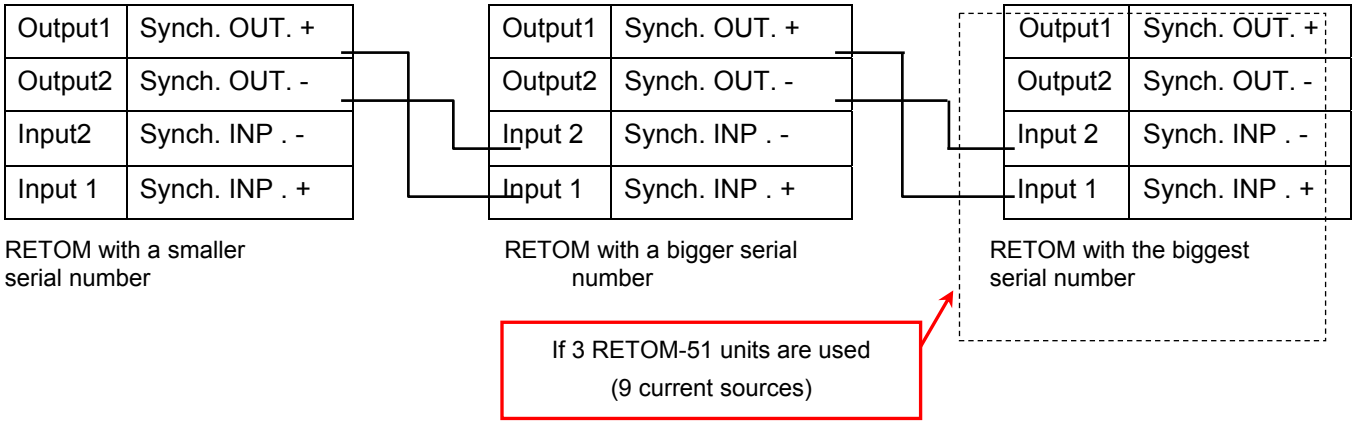


Figure 3.13.2 – Connection diagram of several RETOM synchronization lines

3.13.3 How to Work with the Program

The program main window is shown in Figure 3.13.3.

As this program is a supplement to program “Independent current and voltage source manual control”, its detailed description can be found in this program description. Specific feature of the 6 (9) current source control program is that virtual instruments - Ammeter, Voltmeter, Phase meter, Time lag meter, Frequency meter - change current values of RETOM-51 device with a smaller serial number. For second and third RETOM-51 devices currents and their phases control is performed via auxiliary window located above the main one. Change of currents and their phases is made either with “mouse” using buttons or keyboard up/down and right/left arrow buttons. To register operating current and time contact polling is performed only in RETOM-51 with smaller serial number (program main window). If it is necessary to connect relay contacts to second (third) RETOM-51, you can open two (three) RETOM-51 program instances and select module “Independent current and voltage source manual control”, where current/voltage control and operation/reset time recording are performed in every program.

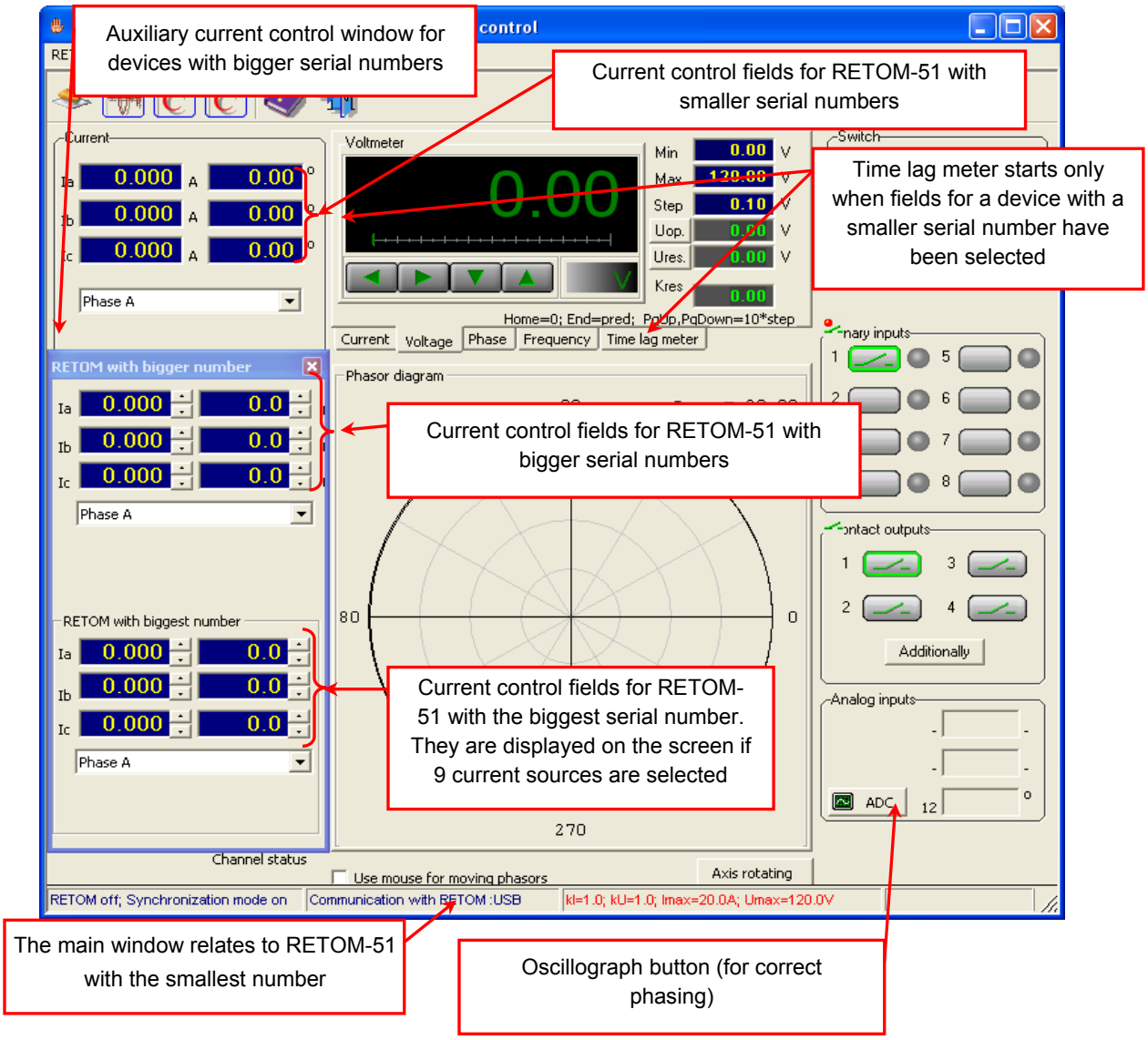

Auxiliary current control window for devices with bigger serial numbers
Current control fields for RETOM-51 with smaller serial numbers
Time lag meter starts only when fields for a device with a smaller serial number have been selected
Current control fields for RETOM-51 with bigger serial numbers
Current control fields for RETOM-51 with the biggest serial number. They are displayed on the screen if 9 current sources are selected
The main window relates to RETOM-51 with the smallest number
Oscillograph button (for correct phasing)
control
Current
Voltmeter
Switch
Phase A
Home=0; End=pred; PgUp,PgDown=10*step
Current
Voltage
Phase
Frequency
Time lag meter
RETOM with bigger number
Phasor diagram
RETOM with biggest number
Additionally
Analog inputs
ADC
Channel status
Use mouse for moving phasors
Axis rotating
RETOM off; Synchronization mode on
Communication with RETOM :USB

Figure 3.13.4 – Program main window

3.14 Archive Handling

All automatic test programs as well as simulation programs have their own archive where results of operation, test conditions and etc. can be stored. *Archive handling* procedure is the same in all programs and includes archive file opening and its saving.

To open file press the toolbar button – *Open* .

To save file press the button – *Save as …* .

Figure 3.14.1 shows a window for opening an archive file with comments:

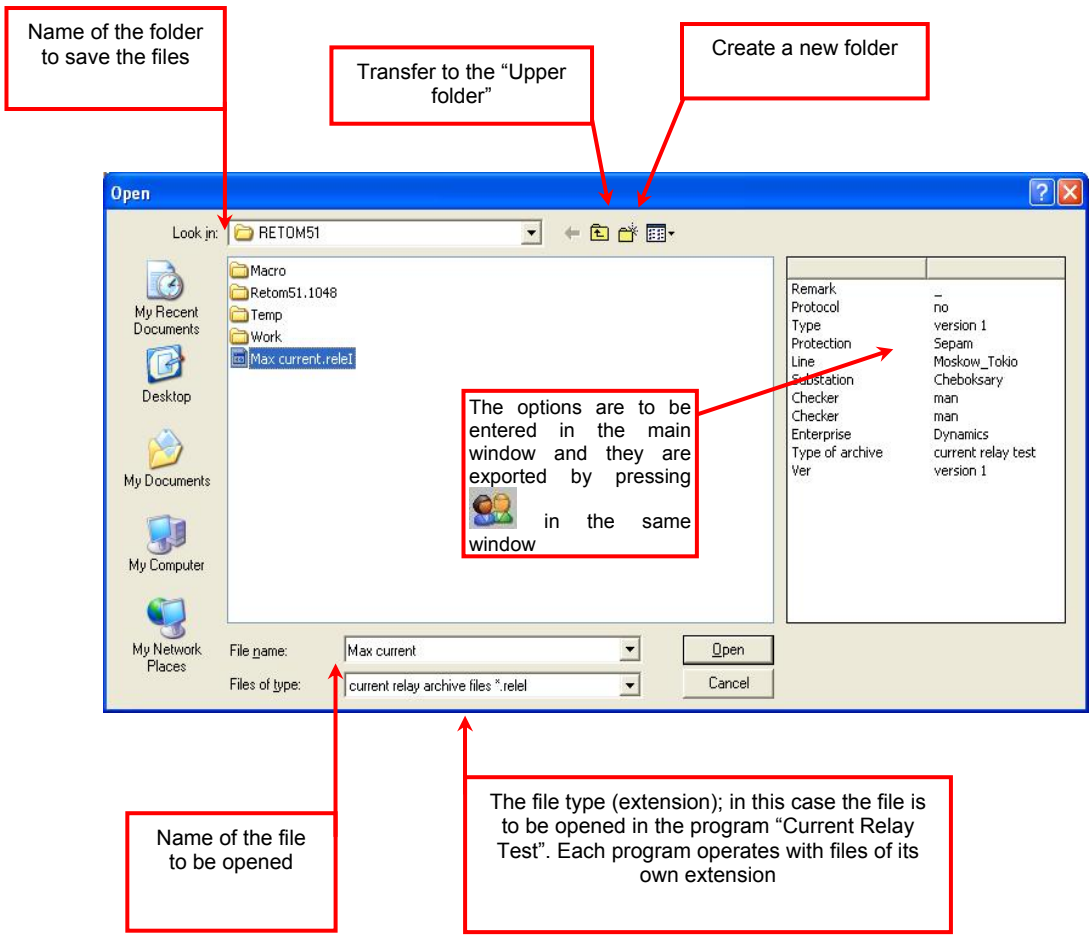

Name of the folder to save the files
Transfer to the "Upper folder"
Create a new folder
Open
Look in: RETOM51
Macro
Retom51.1048
Temp
Work
Max current.relel
My Recent Documents
Desktop
My Documents
My Computer
My Network Places
Remark –
Protocol no
Type version 1
Protection Sepam
Line Moskow_Tokio
Substation Cheboksary
Checker man
Checker man
Enterprise Dynamics
Type of archive current relay test
Ver version 1
The options are to be entered in the main window and they are exported by pressing in the same window
File name: Max current
Files of type: current relay archive files *.relel
Open
Cancel
Name of the file to be opened
The file type (extension); in this case the file is to be opened in the program "Current Relay Test". Each program operates with files of its own extension

Figure 3.14.1 – Window for opening an archive file with comments

If it is necessary to safe a file (e.g. after a test is completed) press the button <*Save as …*> - the same window opens, but instead of the button <*Open the file*> the button <*Save*> appears and you should enter any file name in the field *File name*. Each program will add its own filename extension; files with other extensions will not be read.